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ABSTRACT

This document contains the reports of the travel grant awardees who participated in the eighth International Congress on Mathematics Education (ICME-8) in Sevilla, Spain, July 14-21, 1996. The support of these awardees marks the importance placed on mathematics education in the United States and participation in the international congresses. This document includes the individual reports of the awardees emphasizing sessions attended, reports on the content of the working and topic groups in which the awardees participated, and information gained from ICME-8. Reports are organized by level according to elementary school, middle school, high school, supervisor, community college, university and adult education. Finally, an overall summary of the reports is given. Appendixes include a roster of travel grants and information on attendance assessments. (ASK)

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Observations by U.S. Participants on ICME-8

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REPORTS

on the

EIGHTH INTERNATIONAL CONGRESS ON MATHEMATICS EDUCATION

(ICME-8)

of

TRAVEL GRANT AWARDEES

Compiled by

Jerry P. Becker

with the assistance of

Joan Griffin and Ann Assad

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Name	Representing
Jerry Becker (Coordinator)	U.S. National Commission on Mathematical Instruction (USNCMI)
Sadie Bragg	Mathematical Sciences Education Board (MSEB)
Gail Burrill	President, National Council of Teachers of Mathematics (NCTM)
John Dossey	Chair, U.S. National Commission on Mathematical Instruction (USNCMI)
Marilyn Mays	American Mathematical Association of Two-Year Colleges (AMATYC)
Jack Price	Past-President, National Council of Teachers of Mathematics (NCTM)
Linda Rosen	Executive Director, National Council of Teachers of Mathematics (NCTM)
Alan Schoenfeld	Mathematical Association of America (MAA)

INTRODUCTION

These are the reports of the travel grant awardees who participated in the Eighth International Congress on Mathematics Education (ICME-8) in Sevilla, Spain, July 14-21, 1996. The support of the awardees marks the importance placed on mathematics education in the United States and participation in the international congresses.

The project has its origin in the U.S. National Commission on Mathematical Instruction (USNCMI). The Commission was unanimous in recommending that travel grants be provided to a significant number of U.S. mathematics educators to participate in ICME-8 and that the National Council of Teachers of Mathematics administer the project. A proposal was prepared by Jerry Becker with the assistance of John Dossey and John Tucker. It was submitted to the National Science Foundation by the NCTM. The main purpose was to request support to enable the participation of U.S. mathematics educators in ICME-8, both to contribute to the scientific program and discussions and to disseminate the findings.

A Committee handled the arrangements: announcing the travel grant program, sending and receiving applications, sorting and evaluating the applications and selecting the awardees in the following categories: elementary school; middle school; high school; supervisor; community college; university; and adult education. The Committee also organized an orientation session for the awardees in Sevilla just before the congress convened. Afterwards, it arranged for reporting sessions on the programs of the NCTM and MAA and for receiving the reports of the travel grant awardees and compiling them into this volume. All this was done with the support of staff members in the headquarters of NCTM.

What follows are the *individual* reports of the awardees. Each awardee was asked to (i) indicate what sessions were attended, (ii) report on the content of the Working and Topic groups in which they participated, and (iii) write what was learned at ICME-8. The reports are organized according to elementary school, middle school, high school, supervisor, community college, university and adult education. An overall summary of the reports is given at the end. Appendix I gives a Roster of Travel Grant Awardees and some descriptive information: state, gender, ethnicity, teaching level, working and topic groups and previous ICMEs that were attended. Appendix II give the titles of the Working and Topic groups and names of awardees that participated in them.

An undertaking such as this travel grant program involves a great deal of effort on the part of many people. So, it is appropriate to make certain acknowledgments. On behalf of the Arrangements Committee, I want to express appreciation to the following for their timely and significant contributions:

- to the National Science Foundation for the funding and for expert advice on several matters at crucial times;
- to the awardees who participated and wrote their reports on ICME-8;
- to Linda Rosen, Jim Rubillo and the NCTM Headquarters' staff who managed much of the activity in support of the Committee and disseminating this volume;
- to John Dossey and John Tucker for insightful suggestions while preparing the proposal;
- to the ICME-8 organizers in Sevilla who provided generous help and cooperation regarding various matters being handled by the Committee;
- to Ann Assad who read the reports and prepared an overall summary of them; and
- to Joan Griffin who organized the reports in expert fashion, put all of them into common format, assisted in light editing of the reports and prepared this document on the microprocessor.

Jerry P. Becker
Coordinator, Arrangements Committee
Southern Illinois University at Carbondale

TABLE OF CONTENTS

INTRODUCTION i

REPORTS 1

ELEMENTARY

Monica Chi-Benedetti, Nordale Elementary School/Fairbanks, Alaska 2

Maria D. Gomez, Los Angeles Unified School District/Los Angeles, California 6

Brenda H. Hammond, William Tyler Page Elementary School/ Silver Spring, Maryland 10

Sheryl L. Riley, Glendover Elementary School/Lexington, Kentucky 14

Juana A. Wilson, De Zavala Elementary School/Houston, Texas 18

MIDDLESCHOOL

George E. Abshire, Jenks East Middle School/Jenks, Oklahoma 23

Jane A. Ryder, Dean Intermediate School/Cypress, Texas 28

Elizabeth Fanny Sosenke, Park Tudor School/Indianapolis, Indiana 32

Frederick L. Uy, United Nations International School/New York, New York 38

HIGH SCHOOL

Gail Burrill, University of Wisconsin-Madison, Madison, Wisconsin and National Council of Teachers of Mathematics/Reston, Virginia 43

Sherry L. Cox, Dobyns-Bennett High School/Kingsport, Tennessee 45

Evan M. Glazer, Glenbrook South High School/Glenview, Illinois 50

Roberta K. Koss, Redwood High School/Larkspur, California 56

Mark Saul, Bronxville Schools/Bronxville, New York 61

Richard T. Seitz, Helena High School/Helena, Montana 65

Daniel J. Teague, The North Carolina School of Science and Mathematics/Durham, North Carolina 69

SUPERVISOR

Therese A. Jones, Amarillo College/Amarillo, Texas 73

Donna M. Simpson, Homewood-Flossmoor High School/ Flossmoor, Illinois 77

Linda P. Rosen, National Council of Teachers of Mathematics/ Reston, Virginia 82

COMMUNITY COLLEGE

Marilyn E. Mays, North Lake College/Irving, Texas 87

Cheryl S. Cleaves, State Technical Institute at Memphis/Memphis, Tennessee 91

Raymond P. Guzman, Pasadena City College/Pasadena, California 93

Margie J. Hobbs, State Technical Institute at Memphis/Memphis, Tennessee 98

Jacek Kostyrko, Kenai Peninsula College/Soldotna, Alaska 101

Lynnell S. Matthews, Bowie State University/Bowie, Maryland 104

UNIVERSITY

John A. Dossey, Illinois State University/Normal, Illinois 108

Sadie C. Bragg, Borough of Manhattan Community College/ Manhattan, New York 115

Sunday A. Ajose, East Carolina University/Greenville, North Carolina 119

Lillie R. Albert, Boston College/Chestnut Hill, Massachusetts 122

John W. Alexander, Jr., National Academy of Sciences/Washington, DC 126

Joanne R. Becker, San Jose State University/San Jose, California 130

Thomas J. Cooney, University of Georgia/Athens, Georgia 135

Frances R. Curcio, New York University/New York, New York 142

Beatriz S. D'Ambrosio, Indiana University-Purdue University at Indianapolis/Indianapolis, Indiana 147

Helen M. Doerr, Syracuse University/Syracuse, New York 151

Douglas A. Grouws, University of Iowa/Iowa City, Iowa 156

Peggy A. House, Northern Michigan University/Marquette, Michigan 159

Victor J. Katz, University of the District of Columbia/Washington, DC 163

Glenda Lappan, Michigan State University/East Lansing, Michigan 167

Miriam A. Leiva, The University of North Carolina at Charlotte/ Charlotte, North Carolina 172

Mary M. Lindquist, Columbus State University/Columbus, Georgia 176

Judy S. O'Neal, North Georgia College/Dahlonega, Georgia 180

Judith T. Sowder, San Diego State University/San Diego, California 186

Zalmin Usiskin, University of Chicago/Chicago, Illinois 191

Laura R. Van Zoest, Western Michigan University/Kalamazoo, Michigan 197

Jerry P. Becker, Southern Illinois University/Carbondale, Illinois 202

ADULT EDUCATION

Lynda B. Ginsburg, University of Pennsylvania/Philadelphia, Pennsylvania 213

GENERAL SUMMARY 217

APPENDICES 222

ROSTER OF TRAVEL GRANTS 223

ATTENDANCE AT SESSIONS 226

REPORTS

Monica Chi-Benedetti

Nordale Elementary School

Fairbanks North Star Borough School District

Fairbanks, Alaska

I. Sessions Attended:

During ICME-8 I attended:

Working Group 9: Innovation in assessment

Topic Group 10: Problem solving throughout the curriculum

Regular lectures:

Patricia Campbell: Transforming mathematics instruction in every elementary classroom--using research as a basis for effective school practice

Peter Bender: Basic images and ways of understanding of mathematical concepts for all grades

Peter Galbraith: Issues in assessment--a never ending story

Video: Paolo Freire

Workshop:

Games in the mathematics classroom

All four plenary lectures: Miguel de Guzman, Anna Sierpinska, Jan de Lange, David Tall

II. Working Group 9 Summary: Innovation in assessment--classroom assessment to aid learning

Five different classroom assessment techniques were presented. Issues of concern included the validity of problems teachers used to assess students, the effectiveness of assessment if the teacher was not proficient in mathematics, and tools to help teachers to become better in developing assessments in mathematics. The notion of teachers contributing and using a tested data bank of problems for classroom assessments was discussed. Currently, the only data bank known to be used by elementary teachers is in France. The greatest concern of classroom teachers is being proficient at assessing in all areas in which they must teach and time constraints. Presenters felt that one small step towards improved classroom assessment was better than no change. Teachers agreed to revisit this seriously upon return to their classrooms and to provide feedback to presenters. All of the assessments relied on subjective teacher interpretation and representation of students' learning through the use of letter grades or percentages. This was also a concern at all educational levels.

Topic Group 10 Summary: Problem solving throughout the curriculum

There were several concerns in the area of assessment and problem solving. All presenters agreed that there was a need to teach and practice problem solving in the area of mathematics. Moreover, the problems used to develop problem solving skills must be practical and relevant to the student's life. However, each presenter had a different concern regarding the assessment of problem solving activities. One presenter was concerned with the actual goal of teaching problem solving. He felt that some teachers were unsure as to the purpose of problem solving. Therefore, could these teachers then teach problem solving?

Another was concerned with time for problem solving versus the quality of mathematical learning. She felt that to develop a realistic problem solving activity and then an assessment tool aligned with the problem was not practical for the classroom teacher. Moreover, perhaps the teacher would write an activity to fit her assessment tool. Another concern was whether collaborative practice applied to assessment. The question being, "Does assigning a group grade reflect the mathematical competence of each member of the group?"

Still another presenter felt that there are some major obstacles to overcome before problem solving could be assessed effectively. These obstacles include the: 1) emphasis on communication only, 2) lack of mathematical substance in selected activities, 3) existence of promoting guessing and decreased emphasis in the development of technical skills, 4) applications asked in the problem solving situation making no sense to the student, and 5) excessive classroom time required for problem solving activities. Overall, there are some serious concerns in developing assessments for problem solving activities. However, it was clear that students benefit from such activities at all grade levels and teachers should continue to allow for exploration in this area.

III. What I Learned at ICME-8

Throughout the congress, there was an emphasis on developing collegiality among all levels of mathematical educators as well as discussing current and on-going issues in mathematics education. The teaching of mathematics involves an inter-dependent system of individuals from parents, elementary school teachers through post-graduate professors and pure mathematicians. All are involved in the process of developing students' mathematical thinking and skills. With the development of a broader collegial network, students would benefit from the strengths of all individuals involved.

It is also true that math teachers need to continually move forward on the path toward a fuller understanding of mathematics, not just proficiency at the level they teach. Moreover, they also need to demonstrate abilities to assess the math being taught as well as to analyze the data collected.

A look at mathematics curricula reveals that math is a sequential and systematic field of study. However, teachers are neglecting to teach certain areas of mathematics for a wide range of reasons including lack of time, unfamiliarity with the topic, and fear of math. These individual fears and concerns can be remedied through collaborative collegiality.

It was quite clear throughout the congress that the uses of technology in conceptual math development have not been fully achieved. Granted, students can operate calculators and computers with efficiency and purpose. However, they exit math programs with technical knowledge and a lack of conceptual mathematics knowledge. David Tall in his plenary lecture asked whether educators knew if they had taught process (rote learning of math skills) as well as conceptual mathematics knowledge or just process through the use of technology. Thus, has the urgency to utilize technology in the classroom come at a cost to students' conceptual math development?

The most intriguing research presented has to be David Tall's notion of precepts. He suggests that traditional teaching of mathematics is not adequately preparing students for math at the university level. Tall further suggests that educators must look at reasons for maintaining rote learning practices in mathematics rather than adopting new or modifying existing practices which develop mathematical thinking. His challenge is to develop methods to teach conceptual mathematical thinking to all students.

There is obviously a need to determine why students do not succeed in mathematics at an early age. My purpose in attending ICME-8 was to learn some practices which I could apply in my classroom to meet the wide range of student knowledge and abilities. However, I returned with the notion that the picture was far bigger than my classroom, and I need to do more than I feel comfortable doing. As a result, I have applied for a course to develop a technology framework in the area of mathematics within my district. Also, I have volunteered to serve on the Technology Committee at my school.

In closing, I would like to thank the National Council of Teachers of Mathematics, the National Science Foundation and the Arrangements Committee for the opportunity to participate at the international level. It is not often that primary school teachers are considered in the overall picture of mathematics education. The financial support to assist us in getting to ICME-8 reflects your commitment towards broadening this perspective.

Maria D. Gomez

Los Angeles Unified School District
Los Angeles, California

I. Sessions I Attended

My purpose in attending ICME-8 was to get a global perspective on two specific issues: gender in mathematics and math education for gifted students. Also, I was looking forward to networking with other elementary math educators from around the world. The discussions that arose in the working group sessions, topic group sessions and in the other lectures proved to be very beneficial in developing a math program for those particular students in my school. In addition, I was somewhat surprised to learn that the issues raised by the president of the University of Seville in the opening ceremonies were pertinent to issues that we are struggling with here in the U.S. In California, as in Spain, teachers are trying to deal with the questions of how to make math relevant to the social environment of our students, how and when do we teach basic math skills, why are students dropping out in their first year at the university level, and what makes a good math teacher. The lecture crystallized the point that communities around the world have many concerns, problems and issues in common.

II. Content of the Working Group and Topic Group Sessions

The discussion that centered around Math Education for Gifted Students in the working group was not only was informative but also predictable. It was informative in that it provided a glimpse into the gifted curricula of other countries. In Australia, teachers are developing a framework which links problem solving, problem posing and math concepts which will increase the achievement levels of gifted students. In Korea, the math curriculum reform will emphasize problem solving for students who have high scores in math computation. The same was true for students in Kuwait. In Bulgaria, teachers working with gifted students prepare them for math competitions, help them write scholarly papers and assist them in completing creative tasks.

In the second session of the working group, the participants reported on how gifted students are identified and grouped for instruction. Not surprisingly, in many countries gifted children are tested at a very young age, tracked into rigorous academic programs and segregated in separate schools. Many participants, particularly those from third world countries, reported that most students in gifted programs were males. I reported on how in Los Angeles we have magnet schools for "gifted" and "highly gifted" students and how we are trying to address the linguistic, socio-economic and cultural needs of minority and/or limited English-proficient gifted students.

In the topic group on gender and mathematics, a panel of female mathematicians led a forum on the disparity in the number of females in math education. An Italian participant reported that there were some forty female math department chairpersons at the university level. On the other hand, in Sweden there isn't a single female math department chairperson at the university level. This surprised me and others in the group since Sweden is considered a very progressive country in terms of equal access and opportunities for women. The Swedish panelist reported that efforts are being made to remedy this situation. They have single sex math classes for the beginning two years of high school, there is a summer Ph.D. math program open to all women from the Nordic countries, and there are funds available for female math professor positions at the universities. The panelists from Australia and New Zealand also reported on the dismal statistics for female math educators in their public schools and universities. I was rather disheartened to discover that in many countries women still have many careers closed to them. I found this especially true for countries like Australia and New Zealand though they are so highly regarded as being on the forefront in the reform movement. This isn't to say that I believe that we've achieved full equality for women here in the States. It's just that in our country there is a growing realization to the fact that we've been failing our female students in educational settings and efforts are being made to change the status quo.

III. What I Learned at ICME-8

At the congress there were so many issues that I wanted to explore that it took me some time to finally decide on a couple that were relevant to me professionally. In my role as a mentor teacher for the district, I assist many new teachers with classroom management, teaching strategies and curriculum. Thus, I was extremely interested in probing the state of teacher education and teachers' attitudes toward mathematics in other parts of the world.

Many countries are directing their teacher education programs towards improving the math skills, math content and conceptual understanding of their elementary and middle school teachers. This is precisely what we, in California, have implemented in schools via the Math Projects which are affiliated with local universities. In China, the research indicated that a school's teaching level was determined by its teachers' teaching abilities. A primary goal for them was to raise the level of their teachers' professional development. They are also revamping the curriculum in middle schools to diversify their teaching methods to include a variety of teaching strategies, computer technology and applying math concepts to real world problems. In Bulgaria, where teaching math is steeped in tradition, they have formed a triad where traditional ideas, new ideas and Western reform ideas all link together. Students will experiment with mathematical objects, investigate their properties, formulate conjectures and verify them. In Lithuania, they are looking at the impact of general changes in their math education, the changes in objectives and context of school mathematics and a need for a national assessment tool. In Finland, teacher education has focused on the process of mathematical thinking and methods of assessment. They have also explored the production of new instructional materials which emphasize problem solving and project work.

It became evident to me that the effort made by American educators in retooling our math curriculum is a gigantic step ahead of the effort made in other countries. Many participants noted that they were looking at the U.S. as the model for implementing their programs. I felt very appeased that so many people looked to us in leading them in the reform effort. The feeling that so many teachers in the States have is that the other countries are doing so much better than us in mathematics, and shouldn't we be focusing on "basic skills" like they are? All too often as I visit and talk to teachers around my state, I find them to be intimidated by the reform efforts. They fear that students won't master "basic skills" if we put too much emphasis on problem solving and conceptual understanding. So they compliantly use manipulatives, cooperative groups, investigations, problems and exercises—but they do so hesitantly. Day after day they are reminded by the media, politicians and the public of how poorly our students fare on tests when compared to students from other countries like Japan and Germany. Yet, participants from those same countries reported that they're changing their math curriculum to empower their students to be mathematical thinkers and problem solvers.

I left the congress with a wealth of information which I will share with my peers in Los Angeles in an effort to help them embrace the reform efforts willingly.

Brenda H. Hammond

William Tyler Page Elementary School
Silver Spring, Maryland

I. Sessions I Attended

Plenary Session 1	Anna Sierpinska: Whither mathematics education?
Plenary Session 2	Miguel de Guzman: On the role of the mathematician in mathematics education
Working Group 12	Curriculum changes in the primary school
Topic Group 6	Mathematics teaching from a constructivist point of view
Workshop	Using pop-up engineering to teach mathematics concepts
Regular Lectures	Changpei Wang: Mathematics education--an Oriental point of view
	Patricia Campbell: Transforming mathematics instruction in every elementary classroom--using research as a basis for effective school practice
	Pearla Nesher: School stereotype word problems and the open nature of applications
	David Moore: New pedagogy and new content--the case of statistics
	Peter Galbraith: Issues in assessment--a never ending story

II. Content of the Working Group and Topic Group Sessions

In Working Group 12 on curriculum changes in the primary school, Allison Millett, of Kings College, London, presented a paper on using and applying mathematics--innovation and change at Greenside School. Ms. Millett investigated those factors which facilitated or inhibited the implementation of "UAM" (Using and Applying Mathematics), the mandated National Curriculum, in a way which permeated the whole mathematics curriculum. There was a lack of shared beliefs among the teachers about the "merit" of "UAM." For some, the need for development came from ideas of "delivery" of the curriculum. There was a prominent shared belief that "teaching by telling" militated against the development of a teaching style that incorporated process skills and the belief that basics needed to be firmly placed before "UAM" could be attempted.

Mental computation and curriculum change presented by Ann Heirdsfield and Tom J. Cooper of Queensland University of Technology, Brisbane, Australia, summarized research that suggests that allowing students to construct their own mental computation should play a major role in the changing curriculum. Heirdsfield and Cooper conducted a longitudinal study in which 104 children (2-4 year olds) were interviewed on mental addition and subtraction strategies and drew implications for instruction.

Graham Jones of Illinois State University presented a talk on using children's probabilistic thinking in instruction and finds that children can use probability at an earlier age and can explore the possibility of chance. He noted key concepts in a probabilistic thinking framework: sample space, probability of an event, probability comparisons, conditional probability, and independence. The key aspects are 1) small group learning, 2) predicting, experimenting, and analyzing, 3) writing, 4) technology, and 5) assessment. He found that attaching numeracy was difficult before third or fourth grade.

In her presentation on raising the roof, Mary Briggs of the Open University in the UK explored the idea that children have to thoroughly understand numbers 1-20 before they have the opportunity to work with large numbers.

In the Topic Group 6 on mathematics teaching from a constructivist point of view, Carolyn Maher of Rutgers University presented constructivism and constructivist teaching--can they coexist? She states that "Within a variety of social settings and in classrooms in which flexibility in the curriculum has made possible opportunities to continue working on problems over long periods of time, children can construct powerful mathematical ideas as teachers restrain from telling them what to do, but listen carefully to their thinking."

III. What I Learned at ICME-8

Each session and group that I attended focused to some degree on problem solving and having students construct their own knowledge. Beginning in a plenary session, a speaker suggested that we "have students look for generalizations, let them ask themselves questions, let them construct their own problems and then make them solve problems." "Solving problems is the message I want to send."

Questioning was a recurring theme. Questions are asked to encourage the children to examine or clarify the validity of their procedure, reasoning, or solution. Questions are asked to compare the similarity or difference between strategies. Often the similarities reflect generalizable ideas that then receive "special attention." Eventually the children learn to ask questions of each other.

Particularly intriguing were probability interview assessment items that can be used with young children.

Here is an example of a sample space assessment—

"I will shake this box." Allow the student to observe that the box contains 4 green, 3 red, and 2 yellow bears. "If you close your eyes and draw a bear from the box, what colors could your bear be? Why?"

An example of probability of an event assessment—

"I will shake this box." Allow the student to observe that the box contains 4 green, 3 red, and 2 yellow bears. "If you draw a bear without looking, which color do you have the least chance of getting?"

Two examples of conditional probability assessments—

1. Two red bears are drawn and not replaced. "I will shake the box again. If you draw another bear without looking, what color would you have the least chance of getting? Why?"
2. "Has the chance of getting any of the colors changed since we began drawing bears? Which colors? Why? Can you use numbers to explain?"

Programmatic and instructional reform cannot depend on isolated heroic teachers who are left to work independently. One major issue affecting development is the nurturing role which the school must provide to enable teachers to engage the change process. Components of this nurturing role include: recognition of individual differences, identification of difficulties connected with the innovation, provision for appropriate individual and collective learning opportunities, provision for reflection and evaluation, and adoption of a flexible approach to time and development.

Teachers need to reflect on why we teach word problems, how we teach word problems, what cognitive research says about word problems, and how we make school activities more relevant to real applications. Too often there is no connection between real life and what we ask students to do. The mathematics is not realistic.

Finally, summarizing Carolyn Maher, classrooms that promote "constructivist teaching" might be characterized by a teacher who:

(1) Provides experiences from which a student can build a powerful repertoire of mental images to draw upon for the construction of representations of mathematical ideas;

(2) Assesses and estimates the ideas that a student has built by observing their activity (model building) and listening to their explanations;

(3) Encourages the students to support ideas with suitable justifications and arguments;

(4) Works to build a classroom culture that encourages the exchange of ideas;

(5) Pulls out and calls to the attention of students differences and disagreements;

(6) Facilitates the organization and reorganization of student groups to allow for the timely sharing of information and ideas;

(7) Encourages student-to-student and student-to-teacher efforts to map representations and develop modes of inquiry that might disclose deeper understanding of discrepancies;

(8) Provides multiple opportunities for students to talk about and represent ideas;

(9) Keeps discussion open and revisits ideas over sustained periods of time;

(10) Seeks opportunities for generalizations and extensions.

Sheryl L. Riley

Glendover Elementary School
Fayette County School Corp.
Lexington, Kentucky

While at ICME-8 in Seville, Spain, I had the opportunity to attend several lectures, Working Group 22 on math, society, culture, and education, and Topic Group 1 on primary schools. Working Group 22 was by far the most useful of these experiences, as it met all four days for 90 minutes each day. The three regular lectures I attended were: What I have learned about problem solving through history and research by Luis Puig, Culture and math education in southern Africa by Paulus Gerdes, and Math and common sense by Geoffrey Howson.

From the lectures, I got a feel for the directions mathematics education is going in other countries. Historically, mathematics has been for the elite few or for the minorities who conformed to the majority culture, learning mathematics in the ways of the majority. However, now many countries are coming to see that the cultures of the native peoples are very valuable in all aspects of education, including mathematics. In southern Africa, for example, the teachers are using "ethnomath" to teach their children. The teachers use the basket-weaving techniques of the older villagers to help teach mathematical concepts. This not only connects the home and the school, but helps validate the child as being an important member of society.

Teachers are also realizing that while we teach math as common sense to children in the early grades, when they get older we expect them to learn new concepts on a faith basis, because not all math is common sense. For example, one speaker mentioned that the multiplication of two negative numbers gives a positive number; to a fourth grader learning this, it can be very confusing. Teachers often just tell the student to remember the rule and accept it on faith. The speaker did not yet have a suggestion to fix this problem, but we do need to be aware of it.

The Working Group 22 was fairly large, with people from many different countries, including Sudan, South Africa, Australia, Morocco, and Denmark. We had 16 speakers, who were divided into 3 groups: social and political, cultures and criticism, and ideology and values.

The first topic discussed was that, as stated before, mathematics is power. The people who have the knowledge control it and its dissemination. As long as students are struggling to learn mathematics, they will not have power. This is a problem in every culture. We also discovered, both from the speakers and the discussions, that the same types of problems exist in every country. We all have too many students in the classes, rural areas are "educationally poor," and we are not sure how to include the minority cultures without leaving the standard ways completely out.

Of the questions raised in this group, many were about including minority cultures. The struggle of autonomy vs. authority in educational theory became very important. The Western cultures believe that the interest of the student is what determines the curriculum (to some extent), and that if the student does not do well, it is because he does not have the aptitude in that area. How many people have heard the excuse, "I wasn't good in math either, so I don't expect Johnny to be."

The Eastern cultures, on the other hand, believe that the curriculum is decided by the syllabus and textbook. If a student is not doing well, it is due to laziness and harder work is required. The number of minutes spent on mathematics homework in one week in Beijing and London is shockingly different. Beijing students spend 218 minutes every week, just on math. London students spend 65 minutes per week on math.

Another question raised in our group was how to incorporate the three types of mathematics believed to exist. First there is the "local knowledge," the mathematics the students come to school with. This is where the minority cultures become so important, because the children come to school with the geometric patterns of basket weaving or the tessellations of ceramic tiles already learned at home. If we use this knowledge and build on it, the children will learn better. The second type of mathematics is "school math." This is better known as process learning, in which students learn the rules and algorithms for solving numerical equations. This should not be the most important and most taught of the three types, but it usually is. The third type of mathematics is "mathematician math." This mathematics is problem solving, logic, and strategy. This is the type of mathematics the NCTM Standards apply to. All three types of mathematics are important in their own way, and all should be incorporated into the mathematics curriculum.

The topic group on primary school mathematics met twice during the week. It was not as useful as I had hoped, as all of the speakers were teachers at the college level who were presenting their research papers. The research they had done was informative but very much common sense. One speaker reported that young children (ages 3-5) do not see number, numeral, and ordinal number as related concepts. Another showed that if we use local knowledge to teach mathematics, the students learn better. One other did research on "pseudo math knowledge," which showed that students may sound more knowledgeable about mathematics than they are. He cited an example of children playing in their classroom store. The children could count money but could not tell him how much the shoes they were buying cost or what that meant. They told him that the number on the shoe was the size, but they didn't know what the size of a shoe meant. To an outside observer the children seemed highly intelligent about numbers and their relationships, but with the proper probing, they really did not know more than superficial facts.

The last researcher reported that in first grade students solved numerical problems mentally with their own algorithms, but by third grade they use the school-taught algorithm of right to left in mental math. This is much more inefficient, yet they still use it. They seem to feel that if it is taught, it is the right way to do mathematics, regardless of the inefficiency.

I feel that ICME-8 was well worth attending. However, I got as much, if not more, from talking to the people on the buses, in my hotel, and on the airplane. Meeting mathematics educators from all over the world and learning about their classes is more beneficial than any research results that might be presented. I had a wonderful discussion over lunch with a teacher from Australia about the problems their country is facing in rural areas. The teachers are not well trained, and the populations of the rural areas are very poor. Also, some of the schools are so remote and hard to reach that the teacher is virtually stranded away from all professional contacts. They have few materials and funds. Much of this sounds very familiar to me, especially after talking to a woman who works with poor Hispanic-Americans in rural Texas. She told me almost the same thing, except that the teachers do have professional contacts.

I also talked with a woman from Uganda, who is in charge of trying to set up their country's first national mathematics educators meeting. Having been to a number of NCTM meetings, and having worked or presented at some, I was able to give her some input. She is at a college, and we will keep corresponding on e-mail.

Working Group 22 participants are setting up their own web site, and the man in charge will publish any papers sent to him, in any language in which they are sent. I look forward to keeping in contact with my friends through this site, as well as learning about their new research. Everywhere I looked people were giving out their e-mail addresses to other conference participants. It seems that the computer age will enable us to better work on solving the problems facing math education today. By working together as a global community, we can make math, education, society, and culture an integral part of our curriculum.

I learned a lot about other cultures and other teachers at the conference, but at the same time I am coming away with more questions than answers. How can we use ethnomathematics in our classrooms? How do you still teach to the majority without losing site of minorities? How can we convince students, parents, and other teachers that the old ways are not always the best ways? My answer to these overwhelming questions is that as we go into the 21st century, we must all work together, sharing our knowledge, experience, research, and friendship, because together we can make a difference.

27

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I. Sessions I Attended

I was able to attend and participate in the plenary and regular lectures, working groups, topic groups and short presentations. I also had the opportunity to present a short paper on problem solving in math and sciences for bilingual children.

II. Content of the Working Group and Topic Group Sessions

In Working Group 12 on curriculum changes in the primary school, we discussed the planning of a curriculum that will build on children's informal mathematical thinking.

Dr. T. Carpenter's presentation dealt with the role of notation, and he mentioned that notation: a) constrains children's solutions limiting, perhaps, children's strategies, and b) is used to show thinking since it allows them to communicate and record. He strongly encouraged the use of manipulatives to first interpret the problem, and later translate it into symbols.

Dr. A. Millet spoke about her "UAM" (using and applying mathematics) theory and the making and monitoring of decisions to solve problems. Her UAM reminded me of the NCTM standards; i.e., mathematical connections and the need to make mathematics relevant to children's world and daily lives.

G. Jones reported that the K-4 mathematics curriculum should include experiments with data analysis, since learning will be optimized because students will be able to "reorganize what they know."

T. Cooper talked about mental addition and subtraction in children. He observed and followed the development of a group of children during a 5-year period. At the beginning of his research, the kids started counting left (L) to right (R), then R to L, particularly in algorithms. The more sophisticated their counting became, the more the number and variety of strategies. The results presented by the speaker showed that kids can develop their own strategies, can use both additive and subtractive techniques and that, after 4 years of using his mental math, had an increased growth of high-level strategies. The key seemed to be that easy mental math should be like a game, and from there, the teacher and students evolve into more difficult tasks.

Topic Group 19: Computer-based interactive learning

Unfortunately for my needs (elementary school level), these sessions were more directed toward computer-based activities at the middle- and high school levels. Mr. Allen talked about the Cabri Geometry program and the possible scenarios for its use, such as in geometry and integration of other subjects with mathematics. Mr. Nicholas promoted the use of Sketchpad; however, he mentioned that this program misses a lot of important subjects and topics. A couple of participants mentioned certain disadvantages of these programs since there is "...a problem between the program and the learner." Logo, with which I am a little more familiar, was mentioned positively by a couple of speakers and participants.

III. What I Learned at ICME-8

My purpose was to learn more about mathematics, enhance my teaching abilities and update my mathematical education background through interaction with professionals from different countries. My areas of interest involve mathematics curriculum reform, preservice teacher education and research in mathematics education.

How can we improve our teaching of mathematics? First, by being learners and going through all the different stages, beginning from ecstasies—when you truly believe that you solved the problem and have the right answer, passing by the pain of having to modify your thoughts because your cognitive background was not enough to help you process the mathematical procedure required by the problem, and, finally, the exhilarating feeling of understanding the question and being able to get the right answer. Only after we have experienced all those feelings, will we be able to understand and teach our students in a more effective and productive way.

Professionally speaking, one of the highlights of ICME-8 was the working group sessions. It gave me the opportunity to be an active participant in the congress as well as to learn from the other attendees.

We started by talking about notation and children's informational mathematical thinking. One of the questions raised was, "How can curriculum be designed to provide children opportunities to build on their informal mathematical thinking? " I believe that notation is the result of children reflecting on their mathematical activities; therefore, the more questioning and high-level tasks given to young students, the better they are going to translate it into notation. What matters is the problem solving ability being developed and not the computational skills.

During our discussion on "related issues" for curriculum, we had a very interesting and somewhat heated argument regarding preservice teachers. I noticed that a lot of the attendees expressed the view that today's problems in mathematics education are caused by "lack of teacher preparation."

I am not only a teacher but also a graduate student; therefore, I believe that I have a tremendous advantage over my peers—in both directions—since I am able to see both sides of the coin. There is no way we can point the finger at the teachers to blame them for something they have no control over—they are not the people responsible for implementing curriculum at the college/university level. They follow "course requirements" that are suggested by the College of Education or mathematical education people. If those requirements do not include a decent number of content courses in the math and sciences, how do we dare to say "lack of preparation?"

It is sad but teachers in America are considered a sub-class. There is no value attached to that profession. I think we should learn from the Japanese and Germans who have the utmost respect for educators and place them on a pedestal. Perhaps we need tougher requirements in order to change people's attitudes.

In research on education for minority students, I learned more about the following: We really need to see what is meant when we talk about quality and equality of opportunities in education. It is not the unequal resources that makes education so different for students. It is the hidden messages which undermine their self-esteem and their school performance. I remember a comment by Raudenbaush, who said that "teachers of low-income children tend to emphasize rote learning and minimize discussion and interaction on cognitive issues. They display little tolerance when low-income children ask questions that are 'beside the point. '"

And what about expectations? There is an inverse relationship between our minority groups and our levels of expectations. The greater the number of minority children in the classroom, the lower our expectations. It was quite a surprise to see that these kinds of negative attitudes exist in the mathematical and educational fields. So, what happens to these minority children when they encounter these attitudes? They become discouraged and consider themselves "unworthy," and, years later, they are what we call "students at risk" or "dropouts." As S. Nieto mentions in his book, the sociopolitical context of multicultural education is that if my teachers believe that I will perform at the lower level, then I will perform in the ways the teachers expect.

Mathematics was an enjoyable experience during my K-12 years; therefore, I am always trying to find better ways to teach mathematics to my young students, and this congress provided me with that opportunity. I was able to talk and interact with math educators from other countries and, in the process, learn from them and their experiences.

As part of my learning experience at ICME-8, I would like to mention the following:

- Miguel de Guzman, in his opening plenary lecture, shared with the public his concerns regarding mathematics education at the elementary school level. I agree with his way of thinking, since I do believe that the young kids are ready and willing to learn as long as the subject is presented in a meaningful way. If teachers feel an aversion to math, kids are going to perceive that feeling and, as a result, the cycle of aversion will continue.
- Mathematics teaching has to change in order to meet the students' needs and their environment. Teachers and students have to realize that math is the foundation of the learning process and that society and businesses expect them to act and perform accordingly.
- Anna Sierpinska mentioned that mathematics is a plane that involves ideology (versus reality), theory and didactic action. Teachers and students should not limit themselves to

a textbook, since learning will be superficial. The beauty of learning rests in the exploratory part—you read and you wonder, and then you reflect and analyze.

- Classroom reality is quite different of what preservice teachers are taught and researchers say. The new teacher has to know the content areas and the social, economical and emotional background of his/her students.
- Students have to learn to think and do problem solving; that is, they have to be taught how to get information, process, analyze and then evaluate it. Mathematical thinking requires a lot of communication; therefore, more stress should be given to the linguistic part. Mathematics is knowing how to do it rather than knowledge itself.
- Increased cooperation between schools and colleges and universities is needed. Mathematics education researchers should have to be more in touch with classroom teachers because they are the ones who know what will benefit the student. Theoretical research—with no real world connection—is not enough for today's world.

George E. Abshire

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I. Sessions Attended

During Monday's opening ceremonies, I attended Anna Sierpinska's lecture on whither mathematics education? and Miguel de Guzman's talk on the role of the mathematicians in mathematics education. I was an active participant in Working Group 1 on communication in the classroom. Susan Pirie from Canada was the person in charge and she did an excellent job. I participated in Topic Group 16 on problem solving throughout the curriculum. During the closing ceremonies, I was moved by both David Tall's lecture on information technology and mathematics education--enthusiams, possibilities and realities and Jan de Lange's talk on real problems with real world mathematics.

II. Content of Working Group 1: Communication in the classroom

Working Group 1 was divided into 3 subgroups. The emphasis in subgroup 1 was the theoretical approach to communication in the mathematics classroom. The primary focus of subgroup 2 was research. I was involved in subgroup 3, evaluation. On the first day our subgroup met, discussion was fragmented and not focused on our subtopic. During the next two days, the group had excellent discussions and reached some closure on the evaluation of communication in the mathematics classroom. There were 3 lectures presented to the Working Group 1 on the first day that we met. In subgroup 3, a total of 6 abstracts were presented. At the conclusion of each session, time was allocated for discussion.

The topic of communication in the mathematics classroom is vast and not easily defined. It is a complicated topic that has many definitions depending on whom you listen to. For example, Hideyo Emori's presentation on evaluation of communication in learning mathematics, can Japanese teachers evaluate the mathematical communication appropriately? focused on low context culture vs. high context culture. Mr. Emori explained that Japan belongs to the countries of high context culture, and that one of the characteristics of Japanese communication is "ambiguity." In other words, Japanese people never express their feelings and opinions directly. One of the big issues of Japan's mathematics education is mis-communication and dis-communication among teachers and students. Oral communication is necessary to understand mathematics. Its importance becomes heightened when the mathematics is not algorithmic—when interpretations are required. Mr. Emori emphasized that "we had better encourage such high context communication in the math class, because the high context communication gives students exciting circumstances of learning mathematics."

The communication in the classroom group did come to some consensus. First of all, communication is one of the most important parts of mathematics education. It is also one of the main pillars of education of all nations. Language is vital to learning mathematics. Communication problems arise because students do not understand what the teacher wants. The road to misunderstanding is paved with good interventions.

Content of Topic Group 10: Problem solving throughout the curriculum

Increasingly the success of mathematical education is being judged by the power which it imparts to students to deal with aspects of their lives at work and at home as informed citizens. This topic group was concerned with theories and practices which give students the power to use mathematical ideas to solve problems arising from within mathematics and from outside mathematics. Topic Group 10 discussed curriculum materials, school organization and structures, assessment, teacher education and philosophical research studies into thinking, learning and teaching. It had four subgroups:

1. Assessment of problem solving;
2. Problem solving and teacher education;
3. Innovative mathematics curricula;
4. Psychological and social factors affecting problem solving.

III. What I Learned at ICME-8

I brought back many new ideas from Seville, but the speaker that had the most impact on me was Dianne Siemon from the Royal Melbourne Institute of Technology in Australia. Ms. Siemon presented the following information from her abstract on patterns of classroom communication to subgroup 3 of Working Group 1:

> Ms. Siemon identified four approaches to children's mathematical problem solving. These were identified and confirmed over the course of two teaching experiments involving upper primary grade children and their teachers. The approaches suggested that differences in motivation, participation, and strategy utilization were associated with differences in situated knowledge and beliefs about what was recognized as evidence of mathematics learning and about how it was appropriate to participate in mathematics classroom activity. A's a result, the second study attempted to challenge the prevailing classroom culture by changing the predominant form of discourse. The analysis of the second study confirmed the four approaches and supported the view that children's approaches to mathematical problem solving could be shifted by an intervention strategy aimed at challenging existing communication norms and values. However, this appeared to be more problematic for the fourth graders studied than for the first and second graders reported in the literature.

Ms. Siemon also presented the information below regarding children's approaches to mathematical problem solving. It generated much discussion and interest in Working Group 1. I have been able to share this information with other mathematics teachers from across the state of Oklahoma at the recent Oklahoma Council of Teachers of Mathematics' 25th Annual Conference on Mathematics Enrichment. With the assistance of the ICME-8 travel grant, the research and information that Ms. Siemon shared in Seville has made its way to the plains of Oklahoma. This information and research generated as much interest and as many requests in Oklahoma City as it did in Spain.

CONCEPTUAL KNOWLEDGE: The four approaches to children's mathematical problem solving associated with four patterns of classroom communication:

I. DIVER: High Conceptual-Low Procedural

- External locus of control for actions
- Cognitive goals attended to more than cognitive actions
- Comprehension strategies: checks, monitors, plans, predicts, links and reflects more on knowledge than on actions
- Access to a variety of strategies, not always well used
- Identifies goals
- Tends to synthesize and analyze data
- Some tendency to conceptually-driven
- Premature closure
- Questions directed more at goals than actions
- Some undirected actions
- Uses labels, understands structure
- Deep approach to learning

II. SURVIVOR: Low Conceptual-Low Procedural

- External locus of control for knowledge and actions
- Unlikely to attend to either cognitive goals or cognitive actions
- Tendency to remember and replicate, but experiences difficulty
- Strong tendency to premature closure
- Tends not to check, monitor, reflect or predict on actions or goals
- Experiences difficulty identifying goals
- Experiences difficulty identifying appropriate actions
- More likely to synthesize than analyze
- Little or no questioning
- Surface approach to learning

III. SOLVER: High Conceptual-High Procedural

- Internal locus of control
- Attends to cognitive goals and actions
- Comprehension and regulation strategies: checks, predicts, monitors, plans, links, introspects and reflects on knowledge and actions
- Uses a variety of strategies knowingly
- Identifies goals and appropriate actions
- Synthesizes and analyses data
- Strong tendency to persist until reasonable solution obtained
- Questions directed at goals and actions
- Directed manipulation
- Uses numbers, labels, structure
- Deep-achieving approach to learning

IV. PLAYER: Low Conceptual-High Procedural

- External locus of control for knowledge
- Cognitive actions attended to more than cognitive goals
- Remembers and replicates, often quite effectively
- Tendency to procedurally-driven premature closure
- Regulation strategies: checks, monitors
- Predicts and reflects, more on actions than on goals
- Tends to assume goals
- Tends to try a range of actions
- More likely to synthesize than analyze
- Questions directed more at actions than at goals
- Surface-achieving approach to learning

Jane A. Ryder

Dean Intermediate School

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I. The following sessions were attended at ICME–8

Working Group 16: The role of technology in the mathematics classroom

Topic Group 19: Computer based interactive learning

Plenary Sessions

1. Anna Sierpinska: Whither mathematics education?
2. Miguel de Guzman: On the role of the mathematician
3. David Tall: Information technology and mathematics education--enthusiasms, possibilities and realities
4. Jan de Lange: Real problems with real world mathematics

Regular Lectures

1. Ethnomathematics--where does it come from and where does it go?
2. National presentation Spain
3. Project Australia
4. Real problems with real world mathematics

II. Content of the Working Group and Topic Group Sessions

A. Some ideas presented in the Working Group 16 session:

  1) Technology and the development of sociomathematical norms in the classroom

    a) Kind of tool to be used in classroom – those that have the potential to contribute to the mathematical process

    b) Even the wrong guess can be meaningful – the wrong guess leads to a better guess

    c) Characteristics of activities

      1) investigative work done in a collaborative manner

      2) students should be encouraged to make their own decisions

        3) students should be asked to write group and individual reports
        4) teacher serves as facilitator

    d) Main characteristics of social mathematical community
        1) use tool to solve problems
        2) build strategies of problem solving
        3) students move from local to global hypothesis
        4) students in one group are able to critique students in another group

    e) Discussion about general learning strategies
        1) it is better that we each work and learn in a way that we understand
        2) every group chooses the way that they want to learn
        3) students prefer their way of learning as opposed to teachers telling
        4) we need to develop an approach that takes into consideration sociocultural as well as individual cognitive characteristics

    f) Social norms
        1) collaboration – very important – it is valuable to evaluate and reflect on one's own and others' problem solving processes
        2) community of learners has to take full responsibility for learning
        3) teacher – orchestrate students learning – lead process of student learning – co-investigate in open activities

    g) Sociomathematical norms
        1) problem and solution need to be meaningful
        2) math problem solving more valuable than manipulations
        3) the way to get the solution is more valuable than the solution
        4) guessing, hypothesizing, and intuition are normative mathematical activities
        5) the community needs to work out what counts as different mathematical solutions, links between different solutions and acceptable solutions

    h) Norms directly related to technological tools

        1) operations based upon repetition tend to be valueless
        2) organization of work as part of exploration process tends to be valuable
        3) using many representations is useful to having a global view
        4) inductive work needs a kind of proof or justification beyond the evidence displayed on the computer

B. Some ideas presented in the Topic Group 19 sessions:

    1) Motivating teachers to develop computer skills
        a) teachers need to be taught computer skills in the same manner in which they are expected to teach students
        b) teachers will need to develop trust in college professors who can come into the classroom and assist the teacher in developing computer skills
        c) older teachers who had no experience with computers while growing up are at risk of not taking a risk to learn various software programs—they need support over a long, long period of time
        d) some school districts offer incentive programs to teachers who take a certain number of hours in computer technology, such as loaning them a computer for their use as well as for their students' use as long as they are employed with that district
        e) teachers who resist developing computer skills will usually transfer to schools where technology is not emphasized
    2) Helping teachers feel secure using technology as a teaching tool
        a) at local level designate and provide stipends for teachers with exceptional computer skills to provide in building, in-service computer workshops as well as assist teachers with technology related problems
        b) hire technology technician part-time to assist in keeping computers in good working order
        c) many teachers report a fear of loss of control of the students when technology is

being used; as teachers become more confident with technology they will be more willing to involve students in exploratory learning situations

III. What I Learned at ICME–8

A. Teachers' beliefs about mathematics and mathematics learning affect their practices. How do we use technology to help change beliefs? (Some interventions inhibit change.)

B. Technology changes the traditional curriculum and helps the teacher think in different ways.

Students must be taught how to use technology so that it enhances learning.

C. For young children, learning needs to be integrated, not separated, into different subjects. Technology can support an integrated approach to learning by providing a rich context for doing math as well as reading, science, art, etc.

D. Teachers need much support to change from dispenser of a pre-determined curriculum to that of curriculum innovator and creator.

E. How do we take the power of technology and make sure that we don't destroy what we already have?

F. Teachers need to develop new styles of assessment in which students are allowed to use tools.

G. Technology is based on discrete mathematics, but is used as a model of continuous mathematics.

H. Software made by teachers is better than software made by commercial companies.

I. Teachers must have confidence.

Elizabeth Fanny Sosenke

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I. Sessions I Attended

Plenary Lectures:

Anna Sierpinska—Whither mathematics education?

Miguel de Guzman—On the role of the mathematician in mathematics education

David Tall—Information technology and mathematics education--enthusiasms, possibilities and realities

Jan de Lange—Real problems with real world mathematics

Regular Lectures:

Ubiratan D'Ambrosio—Ethnomathematics--where does it come from and where does it go?

Patricia Campbell—Transforming mathematics instruction in every elementary classroom--using research as a basis for effective school practice

Gerard Vergnaud—Important cognitive changes in the learning of mathematics--a developmental perspective

David Moore—New pedagogy and new content--the case of statistics

Alba Thompson—Conceptual and calculational orientations in teaching mathematics

Working Group 5—Teaching mixed-ability groups

Topic Group 13—The future of algebra and arithmetic

ICMI Studies—Gender and mathematics education

—What is research in mathematics education and what are its results?

I also attended project reports, project shows, and short presentations (posters and videos).

II. Content of the Working Group and Topic Group Sessions

Working Group 5: Teaching mathematics in mixed-ability classes

Four issues were discussed in this working group: theoretical background, classroom experiences, assessment, and teacher training.

We were first presented with three research studies that support the advantages of mixed-ability classes. Jeannie Oakes talked about three dimensions of de-tracking in the U.S.—changes in technical aspects (curriculum, classroom strategies, etc.), changes in norms and values, and changes in politics. Dr. Oakes gave a description of the research she is involved with (procedures and data) and reported the results of that research. She discussed the differences in beliefs between traditional teachers and mixed-ability teachers. In her study, mixed-ability teachers see mathematics as a series of ideas. They also use different pedagogies. Mixed-ability teachers also believe that teachers and schools are the most important factors in student success. On the other hand, traditional teachers tend to see mathematics as a series of techniques, and see student ability and home background as the most important factor in student success. Dr. Oakes described in some detail the different approaches to teaching used by mixed-ability teachers (use of manipulatives, problem solving, calculators, etc.), and the different values that these teachers profess.

The second research study was presented by Liora Linchevski and Zemira Mevarech from Israel. Their study looked at heterogeneous versus homogeneous grouping from the point of view of mathematics learning (as opposed to looking at the social advantages of heterogeneous grouping). In their study, they analyzed standardized test scores over a three-year period. They focused on low-achieving and high-achieving students and on students who were borderline (at the high end of a low group or top end of the high group). Results of their research favored heterogeneous grouping. First, homogeneous grouping increased the gaps between high and low achieving students. Second, heterogeneous grouping increased the mathematical knowledge of most students. Finally, and against many parents, teachers and administrators predictions, students at the high end of the study ("gifted kids") did not show a decline in test scores.

On the second day my subgroup was presented with three activities/curriculum approaches that are successful in mixed-ability classes. The presenters were Laurinda Brown from England, Zemira Mevarech from Israel, and Rina Hershkowitz from Israel. There were also presentations by group participants on successful activities in their own classroom. We talked about how to group students within a mixed-ability class, how to assess, how to encourage strong math students, and how to give support to the students who are having difficulty with the material.

On the third day we had a presentation by Richard Lesh and Miriam Amit on assessment. The presenters began by discussing the multidimensional aspect of ability, the role of assessment and types of activities geared to a broader concept of ability and assessment. According to Lesh, assessment has three roles: to help teachers improve instruction, to inform students of their progress, and to help policy makers. We were also presented with examples of problems that encourage students to think about powerful ideas in mathematics. These problems entail complex situations, take over an hour to solve, are based on real-life situations, and should be approached in cooperative groups. We also discussed some possible approaches to score solutions to these complex problems.

Finally, on the last day we had a computer conference to have informal discussions with pre-service teachers who are currently participants of the Open University teacher training program in England. The members of the working group and these pre-service teachers had informal conversations about teaching mixed-ability groups.

Topic Group 13: The future of algebra and arithmetic

In this topic group there were several presentations that dealt with the relationship between algebra and arithmetic. First, Joaquin Gimenez discussed the need for emphasizing arithmetic and algebraic sense and meaning. Gimenez talked about curriculum changes that will help the transition from arithmetic to algebra. Second, John Mason focused on generality and particularity in arithmetic and algebra problems. He discussed how and whether we can help students generalize ideas. He also talked about particular, peculiar and general questions and how these different categories of questions fit in the classroom.

On the second day there were presentations that dealt with teaching algebra and arithmetic. Mollie MacGregor discussed how some gaps in arithmetic prevent students from learning algebra. MacGregor gave some examples of students' arithmetic misconceptions and how these misconceptions interfere with the generalization of ideas. The main point made is that we need to use arithmetic to teach algebra. Alex Friedlander showed how he uses spreadsheets in the classroom as a tool to help the transition from arithmetic to algebra. He talked about the advantages of using spreadsheets in general, and in particular about the power of spreadsheet use of recursive formulas as preparation for algebra. Finally, Zbigniew Semadeni discussed the role that mental math and the learning of algorithms have in the future success of students in algebra. His main point was that mental math strategies are closer to algebra than algorithms and he believes that teaching algorithms often impedes the learning of algebra.

III. What I Learned at ICME-8

Attending ICME-8 was a unique professional development experience for me. Before ICME I had attended conferences in which participants were classroom teachers, and the presentations and/or workshops dealt with classroom applications (pedagogical issues and classroom activities). ICME-8 put me in touch with another group of math educators, who raised and discussed a different set of issues, and who opened a door into thinking about more general aspects of math education.

One of the recurring topics in the congress was the nature of math problems. Several presentations helped me think about the types of problems I present to my students. I learned ways to identify good problems, problems that will hopefully help my students construct mathematical knowledge. Anna Sierpinska talked about knowledge as the answer to one's own problems. She talked about the need to present students with mathematical problems that they can own. This made me think about the types of problems I present to my own students. Are those problems I owned, or are they problems that my students own? How can I present my students with problems or situations that they will own? Alba Thompson's presentation focused on what she called the conceptual curriculum. She first presented us with three aspects of the math curriculum: calculational, processes and conceptual. The conceptual curriculum is the one that teachers neglect the most in the classroom. She presented us with ways to identify a calculational oriented curriculum and a conceptual oriented curriculum. Richard Lesh and Miriam Amit's presentation was valuable to me in their approach to identifying problems that will prepare students for the 21st century. Finally, Jan de Lange's discussion was useful to clarify the difference between problems that use situations to camouflage calculations and real problems that use complex situations to teach mathematizing. His presentation gave me a new perspective on what a meaningful situation is and how to think about meaningful problems in my classroom.

A second topic was that of teaching algorithms. Several presentations discussed the possible harm of teaching algorithms in the classroom. The issue of teaching algorithms has been of great concern to me in the past few years. As a middle school math teacher I see my students suffering through the long division algorithm without a sense of what's going on. I was surprised at how many people feel very strongly about not teaching any algorithms in elementary school. I always felt that way about long division, but what about addition and subtraction? An interesting presentation I attended on this topic was a video presentation by Julia Anghileri on the effect of teaching the long division algorithm on third and fourth graders. In the video, many kids who had wonderful strategies for solving division problems "forgot" how to divide after the algorithm was presented to them. In my topic group a presenter also showed how memorizing algorithms has a negative effect on learning algebra. I also had informal conversations with participants on this topic who felt very strongly against teaching algorithms in the elementary school. This is one of the research ideas that I hope to continue to discuss with colleagues at my school.

D'Ambrosio's lecture on ethnomathematics was one from which I learned enormously. I had become acquainted with ethnomathematics during my graduate studies in Boston, but it was a topic that I never really explored in depth. His lecture reawakened my interest in this topic. The socio-political and cultural aspects of mathematics are crucial at a time when more students have access to higher mathematics courses. D'Ambrosio's concern with ethics and mathematics is one that I always shared, although I don't feel I've addressed this concern in my own teaching. His lecture was a starting point for me in learning more about how I can use the teaching of mathematics to improve our society.

The two ICMI studies presentations I attended (gender and math education, and research on math education) were a change of pace in terms of what I had been exposed to. It was interesting to hear more theoretical presentations. ICMI is an organization that I didn't know before the congress, and even though I don't feel part of it, I became interested in reading some results of its studies (in fact, I bought the "Towards Gender Equity in Math Education" book that resulted from the ICMI study on gender and math education). I left the congress with many questions about the relationship between teachers and researchers. Several times during the congress I felt I did not belong there. I felt that some of the research studies that were being reported were not relevant to me, or at least I could not see how they were important in my classroom. On the other hand, there were so many issues discussed in the congress that teachers need to know about! Many of my colleagues do not let their students use calculators in high school, do not let students work in groups, use lectures as their sole means of instruction, or use drill and practice as their main type of assignment. I feel it is very important that researchers and teachers communicate more. I hope that more teachers can attend these types of meetings (PME, ICME, participate in ICMI studies, etc.) in the future. If there is a message I want to bring back to my school, it is the need to learn more about what is going on in research. I hope to pass on to my teaching colleagues the energy and knowledge that I got out of this congress!

Frederick L. Uy

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I. Sessions I Attended

The following are the sessions that I attended during ICME-8: Working Group 21 on the teaching of mathematics in different cultures; Topic Group 16 on the history of mathematics and the teaching of mathematics; the ICMI study group on international group for the relations between the history and pedagogy of mathematics; the ICMI study on perspectives on the teaching of geometry for the 21st century; project report on the multicultural dynamic geometry project; meeting on the international study group on ethnomathematics; Regular Lectures on ethnomathematics--where does it come from and where does it go?; applications reform--a brief history in time; school stereotype word problems and the open nature of applications; culture and mathematics education in (southern) Africa; what responsibility do researchers have to mathematics teachers and children?; and teach kids for their future, not our past. I also attended poster presentations, non-commercial exhibits, the international round table discussion and the four main plenary lectures.

II. Content of the Working Group and Topic Group Sessions

Working Group 21 on the teaching of mathematics in different cultures dealt with issues and concerns not only of the teaching, but also of the learning of mathematics in different cultures. The group met for a total of four days. During the plenary sessions, there were three keynote speakers—two of which presented at the first meeting and the other presented at the last meeting. All speakers' presentations dealt with their research work.

The group was divided into four subgroups: The influences of culture on teaching and curriculum, preparing teachers to teach diversity, cross-cultural research, and mathematics learned outside school. Each member of the working group selected his/her preferred subgroup. Each of these subgroups met separately and had its own key speakers. The speakers were asked to give a

10-minute presentation on their own research work, and after each presentation, the floor was opened for questions.

During the last day of the meeting, all the subgroups convened to hear the plenary presentation of the keynote speaker. Afterwards, each subgroup was asked to present a summary of its findings. Once again, the participants were given the chance to ask questions at the end of the presentations. The final remarks and acknowledgments came at the end.

Topic Group 16 on history of mathematics and the teaching of mathematics, as the name suggests, discussed the relationship and significance of the history of mathematics in the teaching and learning of mathematics. This group met for two days; the first day had four speakers and the second day also had four speakers. On the first day, the meeting focused on using the history of mathematics in the teaching of mathematics at different school levels, while the meeting on the second day presented research studies on the history of mathematics and its role in the teaching of mathematics. At the end of each meeting, the audience had the chance to ask questions about the presentations.

III. What I Learned at ICME-8

ICME-8 gave me an opportunity to learn more and to be more aware of the many issues, research, problems, developments, and status of mathematics education, both nationally and internationally. It also taught me the importance of bringing these concerns into the open and of discussing them with fellow mathematics educators, hoping to find solutions to these concerns.

I have always believed that mathematics occurs outside the four walls of the classroom and my attendance at ICME-8 has reaffirmed this belief. During the subgroup sessions, instances of mathematics occurring outside the classroom and in different cultures were clearly demonstrated by the speakers. For example, one speaker explained how Maori women were able to reason and think mathematically in a Maori context. She showed how these women prepare meals and this preparation exhibited the use of mathematics, primarily the concept of functions. The elaborate process of planning, preparing, estimating, and scheduling is clearly an application of mathematics. These women did not have formal education but learned the process informally.

Even though this use and application of mathematics seems complex, it often is considered, unfortunately, to be limited with low status and values.

Those who have formal education were studied also. Another speaker discussed her research funded by the National Science Foundation (NSF) with regard to the investigation of how middle school students (11-13 years old) use mathematics concepts and processes in a variety of out-of-school situations. This study demonstrated evidence of the students' use of the concepts of estimation and function. They used the concept of function when they plan, work, and play outside school and the concept of estimation when they play music, do chores and recreational activities, shop and do school work. The researcher concluded that students use mathematical ideas naturally as needed.

Secondly, I continually learn about the importance of the history of mathematics in teaching mathematics. Study after study shows the advantages of incorporating history into the lessons used in classrooms. Not only do these lessons enrich the knowledge of the students but also enhance appreciation and awareness of other cultures. Furthermore, these lessons motivate students and the level of participation is remarkable. All the speakers on using history in the teaching of mathematics agreed that students are more enthusiastic and find the lessons more realistic and more concrete. This proves that there is a need to take more than a second look into our teaching of mathematics lessons.

The use of technology in teaching mathematics always has been controversial. To use or not to use, that is the question. Pardon the pun, but this issue needs to be addressed. The NCTM standards have the use of technology and so do I. Oftentimes, the terms technology and calculators are used interchangeably when, in fact, calculators are only a part of technology! Using a graphing calculator does not mean the students are lazy or do not understand what is going on. These tools, yes, they are just tools, enhance the learning process and enable students to investigate and to inquire more. They make learning more efficient. The involvement and enthusiasm students have in using technology elevate their level of learning and thinking. The students influence each other, and what better kind of influence is there than students encouraging and helping each other to learn?

Real-world applications of mathematics are essential in improving the teaching and learning processes of mathematics lessons. When real-world problems are presented to the students, they see the value of the lesson. They believe that mathematics does exist in the outside world and is used even outside the classroom! In addition, real-world applications enable the students to extend the lessons to situations other than what they are exposed to. As educators, we have to look into our own ways and determine whether or not the mathematics problems we give are truly applicable and familiar in the world where our students move.

I also have learned that our mathematics curriculum must be redesigned in order that these above-mentioned teaching approaches can be incorporated in the lessons. As the studies suggest, using these methods in the classrooms allows the students to be more involved and more appreciative of learning. The NCTM Standards recommend these teaching approaches and our students will look at studying mathematics in a more positive manner. Since these approaches were products of research in mathematics education, I have learned that an increased and continued support of research in mathematics education is necessary and fundamental. This research gives numerous recommendations and suggestions on how to improve the teaching and learning of mathematics. Without these studies, education in general simply will head in one and only one direction—regression!

Finally, I learned the importance of meeting other mathematics educators and attending professional development conferences like ICME-8. This often neglected opportunity enables one to communicate and express concerns with others, hopefully to give each other support, to look for a solution to a common problem or situation, to exchange ideas and lessons, or just to talk and get networked. Conferences bring forth important issues and refresh the minds of the participants. Those who are not aware of the latest techniques or teaching methods, of the modern equipment available in the market, of the new textbooks, or of ongoing research in mathematics education are given the chance to enhance their professional development. Most of all, joining a conference brings many benefits personally and professionally; however, the students are the overall winners since they are the direct recipients of these benefits. If the students are the ones benefiting greatly, is there a much better reason why it is important to attend conferences?

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Mathematics Education--An International Overview

The Eighth International Congress on Mathematics Education was held in July 1996, in Seville, Spain. Nearly 4000 representatives from more than 100 countries took part in working groups and topic groups. They heard reports on mathematics education from different countries and discussed perspectives on curriculum, assessment, teaching, and research in mathematics education.

NCTM's Presence

NCTM was well represented. Forty-eight educators traveled to Spain on grants administered by NCTM through the National Science Foundation; two NCTM staff members processed memberships and sold materials at the NCTM booth; and several Council members gave major presentations, including Board member Patricia Campbell.

Along with representatives from Belgium, Brazil, China, and Israel, I served on a panel discussing "Mathematics teachers as decision makers; changes and challenges," which was presented to the entire congress. Our discussion revealed great diversity worldwide regarding the decision-making responsibilities of teachers in choosing textbooks, defining curriculum, and specifying the school structure of mathematics. From the discussion, it appears that one of the strengths in U.S. education is the value it places on teachers as leaders in professional development. Throughout the conference, it became clear that the NCTM Standards have played an important role internationally and have served as resources for other countries as they shape their curricula.

Shared Challenges

During sessions and discussions, issues arose similar to those with which we are struggling in the United States, such as the role and nature of algebra in the curriculum, the many forms and uses of assessment, the effect of technology, diverse teaching conditions, and how to link research to practice. Several speakers' keynote addresses focused on the reform and improvement of mathematics education. They pointed out that buying into a single model of reform might not be appropriate, that we need to pay attention to process and content as a duality, and that we need to move from simply providing materials to actively engaging students in the learning process if we are to have effective results.

Diversity and Commonality

The most exciting aspect of the congress was discussing ideas with teachers from other countries; learning what our colleagues in Ireland teach in statistics; hearing the concern from Japan about how to retain students' interest in studying mathematics; hearing how Australia has used distance learning for professional development; understanding the difficulties of education in some developing countries where the teacher may be able to visit a community only once every several weeks; and contemplating how to teach an entire culture about the concept of number. Even though our cultures differed, our common goals were the same--to find better ways to reach students and to improve the mathematics they are taught.

The mathematical world is growing closer together. Such congresses are an important step in exchanging mathematics education knowledge all over the world. The United States and Canada have much to contribute to the dialogue; thanks to each of you, we can all be proud of NCTM's leadership in mathematics education.

Sherry L. Cox

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I. Sessions I Attended

I participated in Working Group 16 on the role of technology in the mathematics classroom and Topic Group 24 on mathematics competitions. Even though the organizers ran out of official programs on Monday, the day of my arrival, I was usually able to ask a fellow participant to look at theirs and thus to plan my regular lectures. These lectures were:

Per Broman: Mathematics teaching and learning for the future
Christine Keitel: Teaching mathematics anxiety
Luis Puig: What I have learned about problem solving from history and research
Leen Streefland: Historical learning for future learning
Hans Schupp: Regeometrization of school geometry--through computers (cancelled after we waited 30 minutes for the speaker and were told that he was not at the congress)
Alba Thompson: Conceptual and calculational orientations in teaching mathematics

I was also able to frequent the poster sections, the project shows and the commercial and non-commercial exhibits after the regular sessions ended for the day.

II. Content of the Working Group and Topic Group Sessions

Being a part of these groups and meeting over an extended period of time was a new and very satisfying experience. The time literally flew by, as both of my sessions were quite well organized and contained more information than the presenters could impart in the given time frame.

The high school section of Working Group 16 on the role of technology in the mathematics classroom, moderated by Marcelo Borba of Brazil and Brian Hudson of England, was the largest with around 100 participants. Our agenda included hearing Rina Hershkowitz of the Weizmann Institute in Israel present her paper on technology and the development of sociomathematical norms in the classroom, followed by discussion; hearing a brief synopsis of the ten submitted papers by Brian, followed by comments by the authors and discussions; and dealing with research questions and implications for each of us for the future. We heard papers from several countries, including Malaysia, South Africa, Brazil, UK, France, Italy, Japan, Uruguay and Israel. Common threads of our working group included: (1) the role of computers and calculators; (2) changes in the role of the teacher; (3) math processes to be emphasized and de-emphasized; (4) the necessary sequencing reform in the curriculum; (5) motivation by meaningful tasks as well as assessment; and (6) time and scheduling for technology. Universally, we agreed that the mathematics classroom should be viewed as a community of learners involving joint social construction, with the teacher playing the central role of synthesizer. Repeatedly, I heard from many of the countries the same thing that we've been hearing in the United States; namely, that students do not learn mathematics by drill and practice and that they must take responsibility for their own learning. I was very proud of the work we have accomplished in the U.S., as most of the countries are doing well to have graphing calculators in their classrooms, with very few already using computers. I came away with the feeling that we are ahead of most of the other countries due, in large part, to the leadership of NCTM in providing our Standards. I encountered several educators from other countries who are currently members of NCTM and are using our Standards as models in their own countries.

Topic Group 24 on mathematics competitions was fantastic! I believe the moderator was primarily a Frenchman, probably Claude Deschamps, but he never introduced himself, assuming, I imagine, that we all knew him. Our agenda was designed so that a multitude of speakers could present a brief scenario on the status of competitions in their country. Oftentimes I was unable to decipher or to correctly spell their names because of their accents but the overall content was superb. As the math team coach at my high school, I was especially interested in hearing how different countries conduct mathematical competitions and even more interested in establishing networks with some of these presenters. Whether it was Bulgaria, Sweden, Iran, Spain, or the U.S., persuading teachers to be trained and to work with math teams was (and is) a major hurdle. Jordan Tabov of Bulgaria described how they have trained 30 teachers to serve as math coaches for grades 4-7 across their country and how their curriculum has changed as a result. As a former MATHCOUNTS coach, I have long believed (and preached) that the middle school curriculum should be MATHCOUNTS. Many of the speakers told of significant elementary competitions, and I was pleased to hear from Harold Reiter (NC) that we are beginning an elementary competition for grades 3-5 in the U.S. soon.

III. What I Learned at ICME-8

First, I must convey that I learned to appreciate the expertise of our own national organizations in planning and conducting national and international conferences. Being in a foreign country was a totally new experience for me, and I was probably handicapped by being unable to speak any Spanish at all. Still, the benefits gained far outweigh any inconvenience I encountered while there. I believe I shall profit most from the contacts I made at ICME-8--including a young Ph.D. from Portugal, a teacher/math coach from South Africa and several from the United States. We exchanged cards, and I've already heard from two of them by e-mail. The teacher from South Africa gave me several versions of their competitions, and I am sending her copies of old MATHCOUNTS handbooks as well as other tests I've used.

This was my first encounter with "sociomathematical norms" and the idea of the math classroom as a "community" of learners, yet it is perfectly logical. Ideally, the "community" should make many of the decisions in the classroom; realistically, this still is not so. Each of us at ICME-8 expressed similar frustrations: wanting to spend time in class allowing students to devise and carry out meaningful tasks, yet we are bound by state-mandated curricula and end-of-course tests that do not match what the Standards profess to be relevant. As Per Broman so aptly put it, "The industrial society is dying...what kind of society will we have tomorrow?" No one knows but we do know that the "winner will be a problem solver." He also posed a question that I would like to present: "How long are we to educate losers?" We are the only country from which I heard that tries to provide the same education for all our youngsters. In most other advanced countries, students must pass tests to continue their education; perhaps there is something in this for us to consider. Christine Keitel (mathematics anxiety) made a similar comment: "Math for all is a fiction."

More meaningful staff development was an often-repeated need, especially in my working group. Many cited not the lack of money as a prohibitor of technology in the classroom, but a lack of willingness by teachers to utilize technology due to insecurity and unfamiliarity with the technology. Although my own state is near the bottom of the barrel when it comes to funding technology in the classroom, my own system must be near the top. I expected to find the United States, like Tennessee, in comparison with other countries; I was most pleasantly surprised to find that we indeed surpassed all countries present, including Japan, in our efforts to provide the latest technology for our students. Most of the countries are just getting the graphing calculators into the high school classrooms; a teacher from Japan mentioned that the elementary schools still use the abacus along with calculators. Characteristics of technology use in the classroom for the most benefit require that activities reflect pupil choice and include opportunities for collaborative group work, comparing/critiquing and communicating. Derive, Cabri, and the Geometer's Sketchpad were mentioned by several as exemplary software for accomplishing such tasks. While I am sufficiently experienced with the Sketchpad for my geometry classes, I was made to wonder if I should not branch out and try Derive in my classroom. Thus, I have requested more software along with additional hardware for my students to use. I have six computers and a classroom set of TI-81's, but only one of the computers is connected to the internet; and I am on my own as to how to use it to benefit the greatest number of students. The use of the internet was not addressed at any of the sessions which I attended, but the fact that we rush our students through their use of technology so that they do not make the linkage between technology and pencil-and-paper mathematics was addressed by several. One speaker reported that his research has shown that students who do not want to learn math do not see calculators or computers as a good tool, but that good students (who could learn without the advantages of technology) do see technology as a good tool!

I have broadened my understanding of the classroom using technology but have also raised more questions--such as, what should I be teaching and how should I teach it with the available technology? Perhaps by ICME-9 we can measure the influence of technology and be better equipped for its use in the classroom. A message for all of us is to communicate to authors and publishers just what we need for the classroom. (A good example would be to have more materials for using the internet in the classroom, like Evan Glazer presented at the NCTM meeting in San Diego.)

Another item which will affect my teaching immediately is the promotion of girls in math competitions. While I have always encouraged my female students, and feel that I have served as a role model for many, I'm more determined than ever to encourage their participation in competitions. Generally, my best students are female; yet, they do not perceive themselves as good in math and they back away from competitions. Evidence of this comes in our own MATHCOUNTS and Olympiad competitions.

I am still sifting through the assortment of papers and/or booklets which I collected while at ICME-8. These include pamphlets on the mathematics programs in Japan, France and Italy as well as articles on assessment and historical topics.

In closing, I will consider ICME-8 the opportunity of my teaching career, and I want to thank the members of the arrangements committee that made it possible for me to have this experience. I will be presenting soon at an in-service for my own school system and three area counties in two states; I am hoping that the finished report from our working group is here by then so I can share it with area high school teachers. But I will also promote NCTM and NSF for making this available to public school teachers across the United States. Gracias!

Evan M. Glazer

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I. Sessions Attended

Monday, July 15:	Anna Sierpinska: Whither mathematics education?
	Miguel de Guzman: On the role of mathematicians in mathematics education
	International Round Table
Tuesday, July 16:	Working Group 16: Rina Hershkowitz: The technology and the development of sociomathematical norms in the classroom
	Changpei Wang: Mathematics education--an Oriental point of view
	Sol Garfunkel: Applications reform--a brief history in time
Wednesday, July 17:	Working Group 16: Summary and discussion of submitted papers Pearla Nesher: School stereotype word problems and the open nature of applications
	Rudolf Straesser: Mathematics for work--a didactical perspective
Thursday, July 18:	Congress tour to Pueblos Blancos
Friday, July 19:	Working Group 16: Discussion of critical issues
	Hans Schupp: Regeometrization of school geometry--through computers — canceled, attended projects and commercial exhibit
	Topic Group 19: Richard Noss: Constructing mathematical meanings in CBILEs; M. Felisa Verdejo: Computer-based learning environments; Visual reasoning in geometry education; Tomas Recio: Automatic discovery of elementary geometry theorems
	Attendance of short presentations and poster sessions
Saturday, July 20:	Working Group 16: Summary of critical issues
	Alba Thompson: Conceptual and calculational orientations in teaching mathematics
	Topic Group 19: Four-person panel to address CBILE issues Doug McDougall: Teaching learning needs in computer-based geometric environments; Looking back from the future--ICME-8 from the perspective of ICME-9
	Delivery and attendance at short presentations
Sunday, July 21:	David Tall: Information technology and mathematics education--enthusiams, possibilities and realities
	Jan de Lange: Real problems with real world mathematics

II. Content of Working Group 16 and Topic Group 19

Working Group 16: The role of technology in the mathematics classroom

In the first meeting, Rina Hershkowitz from the Weizman Institute in Israel, presented a talk on the technology and the development of sociomathematical norms in the classroom. The objective was to raise issues binding technological tools and the renegotiation of social norms in the mathematics classroom. Social norms include student-to-student interaction patterns that encourage explaining and justifying mathematical reasoning. Activities to promote social norms among students include collaborating ideas, presenting group reports, and constructing global solutions with technology. The teacher's role becomes facilitative: posing questions, raising issues, but not providing information. Desired outcomes of sociomathematical norms focus on student reasoning, the thinking processes involved in problem solving, estimation and guessing skills, and the presence of alternative and multiple solutions.

A brief summary of submitted papers at the secondary level was given by Brian Hudson in the second meeting. The paper topics included studies about spreadsheets, graphing calculators and software packages, Cabri geometry, Derive on the TI-92 calculator, multimedia software, and the role of and changes in technology. One common issue among the papers emphasizes the role of the calculator and computer as a tool. These technologies are used as a medium for communication and a mediator of the teacher-student relationship. A second emerging theme is the changing role of the teacher with the inclusion of technology in the curriculum. The teacher becomes an orchestrator, synthesizer, and facilitator of information whose focus is to support and encourage students in their conjecturing, problem solving, inquiry, and investigations. Changes in curriculum present a third impact of technology in the classroom. Technology provides teachers with the ability to reform curriculum sequence, include new topics, and integrate previous concepts. The utilization of technology also results in a de-emphasis of manipulating mathematical symbols, making numerical calculations, and exercising algebraic algorithms in the mathematics curriculum. Furthermore, technology invites student communication, reflection, social learning, and meaning to tasks.

The next working group meeting provided an opportunity for participants to actively address technological issues with their colleagues. Members formed small groups to discuss the following questions, problems, and issues:

1. What changes (if any) take place in assessment with the use of technology?
2. How differently do students work with graphing calculators and computers?

3. Do we have a good way to talk about motivation? Can we provide a theoretical framework?
4. Do computers complement students or reorganize the way they work? In any case, how do we describe that?
5. Can the technology substitute for proof in the math classes?
6. Identify changes in curriculum with the introduction of technology.

The final working group meeting posed a forum to summarize the previous day's discussions at the elementary, secondary, and university levels. The presentation focused on the changes desired for the role of technology in the mathematics classroom in the following areas: student thinking and motivation, the mathematics curriculum, teacher support, pedagogy, the educational system, individual countries, and assessment.

Elementary level participants came up with the following conclusions:

1. Additional time and support is needed to implement change with technology.
2. Documentation is needed to demonstrate the impact of technology on the educational system.
3. Technology can help shape teachers' beliefs.
4. Technology should be used in individual situations for drill and practice and in cooperative situations for exploratory investigations.
5. The responsibility for learning varies from the software to the teacher.
6. The comfort level of teachers relates to the students' use of the technology according to their responsibility for learning.

Secondary level participants came up with the following conclusions:

1. The nature of the mathematics curriculum and thinking about mathematics needs to be re-examined.
2. The subject knowledge of the teacher affects the use of technology.
3. The motivation of the teacher and student reflect technology use.

4. The learning environment of technology affects learning (i.e., the computer lab versus the hand-held calculator).

University level participants came up with the following conclusions:

1. Changes in the curriculum include re-examining the traditional approach to calculus versus the reform movement. The use of a discrete machine needs to be questioned when it is used to teach continuous mathematics.
2. Changes in pedagogy address the use of technology with large groups, and how to develop a deeper understanding of concepts with technology.
3. Changes in assessment look at the types of questions that are currently being used and how they would change with technology.
4. Changes in teachers include less control as leaders of classrooms and more responsibility as facilitators.

Topic Group 19: Computer-based interactive learning

The goal of the first topic group meeting was to present computer-based learning environments (CBILEs) and raise issues in their epistemology, pedagogy, learning, and design and development. Richard Noss's presentation on constructing mathematical meanings in CBILEs addressed two questions: 1) How can strictly situated knowledge achieve generality? and 2) How can knowledge be embedded within and extracted from a CBILE? Noss suggested that meanings are constructed by actions on virtual objects and relationships within a situation. In M. Felisa Verdejo's presentation on computer-based learning environments, she stressed that technology has transformed from a transmission model to an active constructivist model through CBILEs. In Thomas Recio's talk on automatic discovery of elementary geometry theorems, he stated that dynamic geometry software has helped students discover new theorems that they could not prove on paper.

In the next meeting, a panel of software developers and researchers discussed the impact of CBILEs on learning and studying mathematics. The panel concluded that dynamic geometry software packages have revolutionized the development and understanding of many forms of mathematics. Furthermore, the panel did not place much emphasis on algebraic software packages due to their static nature. A CBILE, in the minds of panel members, incorporates the ability to instantly modify a computer generated model and see the affects immediately in order to formulate a mathematical pattern.

Doug McDougall's presentation on teaching learning needs in computer-based geometric environments focused on the necessity to build a theoretical framework for designing a CBILE system. The framework must focus on the needs of the learner so that he or she may explore, conjecture, and engage in mathematical thinking in an inductive and deductive manner.

Personal Learning Experiences

There were two issues which I attempted to address in Seville. First, according to results published in the Second International Mathematics Study (SIMS), I was curious as to why the United States students had obtained substandard scores in comparison to students in most other foreign countries. In my own teaching experiences, I have witnessed this pattern with most foreign transfer students. Most students who immigrate to my school from European and Asian countries have stronger mathematics skills than their peers in the United States. What are the foreign teachers doing to produce these higher powered mathematics students?

Upon meeting teachers from Japan, Sweden, Brazil, Spain, France, Israel, and Portugal, I realized that they may not be doing anything different pedagogically from my own teaching experiences. These teachers were facing similar conflicts as I am, such as planning and promoting curricular reform, utilizing technology, engaging their students in social learning, and managing with a limited budget. Their students may learn more mathematics because their curriculum is pushed slightly ahead of the United States.

I observed that education appears to play a different role in each country. For instance, students in many foreign countries may enroll in vocational programs to advance in a career, while comparable U.S. students might enroll in higher education programs. Furthermore, I noticed that U.S. schools appear to stress extracurricular involvement more than many foreign nations. As a consequence, assessing a country's students through an international test may not accurately depict the performance and ability of their students.

Another issue I addressed in Spain related to how students learn mathematics with technology. I have been most concerned with the transfer of learning that takes place when a student moves from the classroom to the computer lab, and vice versa. Many teachers at the conference agreed that students have trouble making a connection between the mathematics with technology and the mathematics with pencil and paper. Through the working group forum, we discussed methods to formulate questions and devise assessment activities to help bridge this gap to help improve student understanding. Some teachers contested that they found an increase in student understanding if the technology was situated in the classroom instead of a computer lab. This reasoning has prompted me to consider using the TI-92 calculator, instead of the computer, as a primary tool in the classroom. The flexibility and mobility of the calculator promotes group explorations, class discussions, and whole group reflections. These opportunities may also help bridge the learning gap between technology and pencil and paper skills.

Some people contended that computer learning and pencil and paper learning of mathematics may be disjoint entities. They stressed that students should have the opportunity to view a mathematical concept from multiple representations that are not necessarily linked to each other. In fact, some people promoted several ways of understanding mathematics because it may open students to new ways to think about mathematics.

Overall, the issues addressed at the conference were very thought provoking and the interaction among foreign colleagues was unique. I am pleased to have exchanged e-mail addresses with several people from around the world so I may continue this discourse and hopefully create promising partnerships for the future.

Roberta K. Koss

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I. Sessions Attended

I attended plenary sessions 1, 2, and 3, was a member of Working Group 16 and Topic Group 2, and heard the following regular lectures:

Carolyn Kieran: The changing face of algebra

Tom Cooney: Conceptualizing problems in development of teachers

Urs Kirchgraber: Secondary schools and mathematics teaching in Switzerland

David Moore: Statistics

Peter Galbraith: Issues in assessment

Victor Firsov: Russian standards--political impact on mathematics curriculum, and a panel presentation on geometry for the 21st century.

Additionally, I attended an organizational meeting for T^3 Europe (Teachers Teaching with Technology).

II. Working Group and Topic Group Sessions Content

During the first meeting of Working Group 16 on the role of technology in the classroom, we heard a summary of research on technology and development of sociomathematical norms in classrooms presented by Rina Hershkowitz of the Weizman Institute in Israel. Classroom characteristics that she identified included functioning as learning communities and discussing processes, not procedures. The latter were based on norms suggested by Cobb and Yackel: explaining/justifying solutions and making sense of other's explanations. The research project sought to study how technology could effect these norms. Protocols had students collaborate on given problems, write individual and group reports, and critique each other's work. Teachers facilitated the process and synthesized results. Examples of problems and student work were shared. The researchers maintained that computerized tools played a crucial role in the development of social norms in the classroom, but the examples and work presented seemed to me only to underscore constructivist learning rather than utilization of technology.

During session 2, the working group divided into 3 subgroups: elementary, secondary, and tertiary. Secondary participants heard summary presentations of research relating to spreadsheet use (Malaysia), function plotting/graphing (Japan), calculators (Japan, South Africa, Brazil, Israel), use of Logo (UK), Cabri use (Uruguay), a technology overview (Italy), and a multimedia project (UK).

Brian Hudson did an admirable job of summarizing the major ideas:

(1) The computer/calculator has a role as a tool, as a mediator of student/teacher relationships, and as a medium for communication.

(2) Technology changes the teacher's role—he/she becomes a facilitator/synthesizer, has a key role in implementing technology, and needs major support to make changes.

(3) Processes are emphasized—conjecturing and testing, formulating problems, greater student responsibility, elaborating and validating conjectures.

(4) Less emphasis is placed on symbol manipulation and algebraic manipulation.

(5) Curricular reform is needed—technology makes many traditional topics obsolete and others accessible.

(6) Communication is enhanced—the level of group interaction increases, students communicate about mathematics, and learning becomes a social activity.

(7) Technology serves as a motivater—mathematics becomes more meaningful and relevant to students.

Each participant was asked to submit two or three issues for further discussion. During our last two sessions, we addressed the ideas in small groups and then shared consensus ideas with the full subgroup. Group leader Dr. Marcelo Borba did an admirable job of ensuring that both Spanish- and English-speaking participants understood all ideas.

The topic group on secondary school mathematics was far less effective, primarily because there was little opportunity for discussion. During the first session, Jan de Lange and Zal Usiskin presented their ideas on trends in curriculum and teaching. de Lange listed some problems he feels need to be addressed: What is problem solving? Mathematical reasoning? Which structure should replace the old? How much longer will technology be promising? What is the balance between visualization and other modes? When and how should the class environment be changed? He stated that in order to implement innovation, there must be an underlying philosophy and it must state explicitly how it regards curriculum, instructional strategies, and assessment.

Usiskin gave three global ideas: mathematics (not just arithmetic) is useful, mathematical truth is established by deduction, and algorithms are powerful procedures that allow entire classes of problems to be solved.

During the second session, Glenda Lappan (U.S.), Rina Hershkowitz (Israel), Koeno Gravemeijer (Netherlands), and Brian Greer (U.K.) presented information about their curriculum projects. I left the session early because I was so thoroughly disappointed by the structure of this topic group. In past congresses, most notably Australia, there were real opportunities for all participants to discuss ideas of geometry at the secondary level. I personally had a deja vu feeling of very boring university lectures during these sessions.

III. What I Learned at ICME-8

In general, I would say I gained the most from participation in my working group. This really isn't surprising since more Congress time was allotted to the working groups. The good news is that most countries share mutual problems with technology: availability of hardware and software including both financial problems and location problems for computer labs, defining new roles for teachers and students, dealing with the needed curricular changes due to technology, developing appropriate assessments, and necessary staff development for teachers.

School authorities in Norway require that students purchase their own graphing calculator; schools charge $15 per term for the use of a machine. Denmark and other countries have difficulty obtaining sufficient calculators for classroom use. I was able to make positive suggestions about gaining parent support and loan programs that may be possible sources of equipment. It was reported that about half of the 15-16 year old students in the UK do not use computers in mathematics, even though equipment is usually available. Teachers in Japan are rather reluctant to use graphing calculators; this may be due to the fact that calculator use is not part of the National Course of Study (NCS). The U.S., U.K., Sweden, and Denmark allow the use of graphing calculators on national exams.

On other assessment issues, many participants voiced concerns about fairness. There are often complaints about groups and assessments. Many of us shared our own classroom assessment strategies, including giving a first page of an exam restricting calculator use and the remainder of the exam allowing the use or requiring students to demonstrate multiple approaches to a problem.

Our final discussion centered on attitudes. Teachers experience a loss of control as students begin to use technology for exploration. Technology forces students to take responsibility for their own learning, and they often resent this. The collective mathematics education community must help educate school administrators, parents, and the community regarding student-directed learning.

I gleaned a few comments from the plenary sessions in spite of the poor acoustics, projection system, and audience noise. China is experiencing the spread of compulsory education moving from "education for elimination" to "education for quality." In Australia, many students who formerly would have majored in mathematics are switching to other majors, particularly computer science. The importance of mathematics is being questioned; it's being suggested that too much instructional time is devoted to mathematics and that some can be diverted to other areas.

Carolyn Kieran's research on school algebra seemed rather dated in view of trends in the U.S. Tom Cooney's remarks sparked a tangential idea--I plan to institute a meeting with colleagues in our English department investigating similarities in strategies for poetry analysis and mathematics. Kirchgraber's view of teaching in Switzerland was enlightening. He said gymnasium teachers consider themselves mathematicians first and teachers second; many receive the Ph.D. prior to permanent positions. The description of the curriculum seemed somewhat convoluted, but innovative. He also mentioned that the TI-85 is widely used and the TI-92 is being introduced but is viewed as a transitional machine. Peter Galbraith's discussion of assessment issues provided a good summary. It didn't provide any new insights for me, but the nautical metaphors taken from Kaput and Thompson nicely clarified levels of involvement. Firsov's talk was very enlightening. He first dealt with myths regarding high achievement levels of Russian students on the 1992 IAEP. He contrasted American and Russian schools as diversity vs. unity, liberation vs. suppression, and decentralization vs. centralization. He suggested that the current democratization may move the two systems closer, perhaps toward a golden point!

David Moore's talk on statistics was the most interesting and informative talk that I've heard in years. He spoke of the democratization of mathematics, the quantization of society, and technology's driving change. He dealt eloquently with the synergies between content, pedagogy, and technology. Some of his general conclusions were that content and pedagogy should drive instruction and technology should serve content and pedagogy. As an aside, he said that he can't understand why mathematicians demand precise language rather than clear language. My copious notes will help guide our district discussions as we move toward implementing the AP Statistics curriculum.

Finally, I'd like to thank the arrangements committee, NCTM and NSF for the financial support enabling me to attend this congress.

Mark Saul

Bronxville Schools

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I. Sessions I Attended

I attended sessions of Working Group 23 on cooperation among countries and regions in mathematics education, Working Group 7 on mathematics for gifted students, Topic Group 4 on distance learning of mathematics and Topic Group 24 on mathematical competitions. Among the lectures I attended were Russian standards--concepts and decisions by Victor Firsov, mathematics competitions in China--successes and deficiencies by Zhonghu Qui, social constructivism as a philosophy of mathematics by Paul Ernest, and highlights and shadows of recent Japanese curriculum for secondary schools by Hiroshi Fujita, as well as meetings of the World Federation of National Mathematics Competitions. In the interest of brevity, this report omits discussion of some of these valuable sessions.

II. Content of the Working Group and Topic Group Sessions

The sessions of Working Group 23 on cooperation among countries and regions were perhaps the most varied of those I attended. Murad Jurdak (Lebanon) spoke about the difficulties of finding a common curriculum, even for students of very similar countries (like neighboring Arab states). Kenneth Retzer (USA) gave several interesting examples of work done by Chinese educators. He mentioned that they feel isolated and are interested in making international connections, sharing their results, and cooperating with educators in other countries. Jean-Paul Ginestier (Norway/ Canada) and Ruth Sweetnam (United Kingdom) spoke about their work with the International Baccalaureate program. They described the struggle to avoid, in their curricula, bias towards particular national systems of education and particular cultures, while striving to make it relevant to each student and teacher using the materials.

William Velez (USA) talked about cooperation among cultures in a rather different context. He has been involved in several programs (within the United States) in which research mathematicians seek roles in pre-college education. Aside from the intrinsic interest of his work, the similarity of his discussion to that of other cross-cultural projects (in the more usual sense) was remarkable.

My own talk concerned attempts to transplant elements of Russian mathematics education to the United States. For the past five years, the American Regions Mathematics League (ARML) has organized student and teacher summer exchange programs with Russia. As a direct result of these exchanges, several elements of Russian mathematics education culture were introduced in the United States, including classroom techniques, distance learning programs, competitions, and published materials (the most recent publication, by AMS, is a book of materials used in the "mathematical circles" of St. Petersburg). In order to adapt Russian practices to American circumstances, we often had to change these practices beyond recognition. Yet without a conscious borrowing, these might never have developed in the United States.

The talks in Topic Group 24 on mathematical competitions were closer in style to each other than those in Working Group 23. Some (Soifer, USA; Geretschlager, Austria) presented concrete mathematical results. Others (Tabov and Lazarov, Bulgaria) showed variations in problem posing and in grading contests. In general, the direction of the group's effort seemed to be towards introducing new mathematical content and towards greater freedom for students participating in contests to be creative in their responses.

Perhaps the most remarkable progress in this direction was presented by Maria de Losada (Colombia). Her contest for elementary school students is the best implementation of this concept that I have yet seen. Students are given five open-ended problem situations, of which two are explored in detail. They are then invited, over a three-week period, to explore the remaining three. The most remarkable detail of this contest is its presentation of the problems in comic-book format, by a cast of cartoon characters created for the program. de Losada gave examples of creative student responses that imitated this format.

Topic Group 4 on distance learning of mathematics offered an array of efforts using new technologies to reach some of the oldest cultures on earth. I found that most participants, myself included, had more questions than solutions. Clements and Ellerton (Australia), for example, discussed delivering education by e-mail to remote areas of Southeast Asia. They found that obtaining and installing computers was only the start of their effort; the problem became maintenance of the equipment. My own presentation discussed the work of the Gelfand Outreach Program in Mathematics, which is now run by surface mail. My concern was to find software that would allow for teacher-student communication by e-mail, including the exchange of diagrams and equations. No one at the session was fully satisfied that they had a solution to this problem.

III. What I Learned at ICME-8

Evolutionary biologists have long noted the importance of diversity to the survival of a species. In mathematics education, we have been a bit slower to recognize this connection. What struck me most about ICME-8 was not only the intellectual diversity of the participants, but also how very quickly almost any two of them seemed to find common ground for interaction.

Nowhere was the value of intellectual diversity more obvious than at the talk by Paul Ernest about social constructivism. Ernest's "fallible" view of our subject looks at its development as a social process through which we struggle to agree on what we will think of as mathematical truth. Ernest elaborated both on the history of mathematics and its transmission through education from this viewpoint. Mathematicians in the audience disagreed strongly (and sometimes heatedly) with this view. From their Platonist point of view, mathematics is explored as an object with its own reality, independent of the persons perceiving or describing it. Ernest explains this phenomenon as the result of a mathematical subculture, within which the infallibility of mathematical truth is correctly perceived, but only by those who have already agreed to this viewpoint.

I do not find either of these two viewpoints completely convincing. The Platonist view does not tell us, for example, why mathematics has a history and why certain discoveries were made at certain places and times. The social constructivist view does not adequately explain why different cultures seem to "agree on" substantially the same mathematics or why mathematics is so unreasonably efficient at describing the physical world.

For me, as a classroom teacher, these shortcomings are delightful. They free me to be a Platonist with one student and a social constructivist with another without having to depend on any single view of the rather complex classroom issues that I deal with daily. Often, in working with students, I find it convenient to adopt a "Platonic" pose: the mathematics is there to explore, and we are working together to explore it. I do not find, as some claim, that this leads me to a cut-and-dried teaching methodology. Even when there is something external to know, and even when I know it and the student does not (and Ernest would not use such language), there is room to artfully reveal parts of the picture and let the student explore the rest.

But there are other times, even with these same students, when I have to negotiate on various levels. On one level, my students and I must agree on the meaning of mathematical statements. On another, I must negotiate the relationships among these same statements. On a third, I must find a way to agree with them on the need for doing mathematics--on motivation. This search for motivation ranges from the very simple (Why should I learn to add fractions when I can reach for a calculator?) to the bread-and-butter negotiation about the need for a mathematical way of thinking (Why should we prove such-and-such when we can see that it always works anyway?) to even the most able student looking for insight (Why should I think of the identity $x^2 - 1 = (x+1)(x-1)$ if all I have to do is factor the number 3599?). This part of teaching is all social.

Which view of mathematics is deeper? Which will yield more insight? These are intriguing philosophical questions, but it is not crucial to me that we reach a final decision in this dispute (if that is what it is). To do my job, I must have it both ways. And the best thing for me to hear is discussion, whether heated or reserved, of the ramifications of each viewpoint. Even a philosophical "cruise to nowhere" will help me understand my students and help them understand mathematics.

Richard T. Seitz

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I. Sessions Attended

I attended the following sessions: the two opening plenary sessions by Anna Sierpinska and Miguel de Guzman; the exposition at the Galeria Juana de Atzpuru (featuring the art of Rune Mields and Anton Stankowski); regular lectures: A view of mathematical education from the Chinese point of view (Changei Wang), highlights and shadows of Japanese education (Hiroshi Fujita), mathematics for work--a didactical perspective (Rudolf Straesser), critical mathematics education--some philosophical remarks (Ole Skousnose), a decade of teaching mathematical modeling (Jens Touburg and Soren Wagner), all Working Group 11 sessions on zero-based curriculum, both sections of Topic Group 2, the national presentation on Australian mathematics, a host of short presentations, all of the poster sessions, the ten project shows by various countries, most of the non-commercial exhibitions, all of the commercial exhibitions, a workshop on the mathematics of chaos, an evening performance by the Compania Andaluza de Danza, three happy hours, several evening discussions with Danish and English mathematicians, a tour of the Columbia region, and the two closing plenary lectures by David Tall and Jan de Lange.

II. Content of the Working Group and Topic Group Sessions

Working Group 11 on a zero-based curriculum attempted to define what a curriculum from scratch would look like. The group consisted of lots of presentations on what to consider when designing a zero-based curriculum and what considerations must be made. The progress toward resolving what such a curriculum would look like was just begun. One of the more interesting presentations was from an American high school teacher, Albert Goetz, who made specific recommendations for change involving a high school curriculum with one year of data analysis driven algebra, a second year of topics in mathematics (motion, growth, fractals, tilings and Pascal's triangle), a third year of modeling, problem solving and proof, followed by a final year on specialization in calculus, discrete mathematics or statistics.

Much discussion was concerned with the need to get away from pencil and paper algorithms due to the mental math and calculator usage. The Danes and Swedes presented an interesting view with their elementary education that is based on constructivism. Amazingly, in Denmark, it is forbidden to teach traditional algorithms—the children develop their own.

Topic Group 2 on secondary education examined the current state of education being developed in several countries. American and Dutch views of mathematics applications and constructivism were discussed heavily with Zal Usiskin and Jan de Lange presenting some poignant views on what should be the major components of secondary learning. The major world-wide trends that they discussed were listed by de Lange as:

1. Problem Solving
2. Thinking/Reasoning
3. Integration
4. Technology
5. Visualization
6. Flexibility
7. Learning environment

III. What I Learned at ICME-8

I was able to make some important friendships with this conference. I look forward to co-authoring some articles with high school mathematicians across the world. The experience that NCTM provided to me was exceptional. I thank the arrangements committee for the support. Rather than list all of the things that I gathered at this conference, I will highlight some presentations and the thoughts I gathered from the speakers and their talks. Listed below are some of the most noteworthy.

Bloomfield and Sanders (UK)—Teacher education--going from a novice to expert

Successful teaching involves:

- a learned teacher—one who has the background in mathematics and pedagogy along with experience in teaching

- an empowered teacher—one with the authority to control his/her teaching
- a reflective practitioner—a teacher who takes time to reflect on teaching practices and evaluate teaching
- a mentoring teacher—with experience and success comes the responsibility to pass on that success within a mentoring capacity.

Hugh Burkhardt—Implementation of zero-based curriculum

Reform involves various types of change. Look for the changes below to evaluate the degree of reform in a project.

- mathematical content, including technology and structure of mathematics
- types of student tasks, including non-routine or non-standard problem solving
- mathematical processes implied by the tasks—may include Polya's steps
- ways students communicate—written, using technology, etc.
- ways teachers are expected to work with groups.

Zalman Usiskin—Big ideas in mathematics

- Mathematics (not just arithmetic) is useful.
- Mathematical truth is established by deduction and deduction alone. Proofs are done for important reasons.
- Algorithms are powerful procedures that allow entire classes of problems to be solved.
- Representations and morphisms are powerful mechanisms for understanding and doing mathematics.

Jan de Lange—Current status of secondary mathematics education

What we have left are concerns that we must face to continue with the present reform in mathematics.

- Teaching mathematics is very hard.
- Where are the basic skills?
- Where is the structure?
- What are the goals?

Time is critical for concept development; it is less critical for transfer of those concepts.

Rudolph Strasser—Vocational mathematics

Students can solve problems at work.

The math used on the street is:

- learned there
- efficient
- different than learned at school

Tarp and Seitz—Conversations and closing thoughts

As I listened to so many speakers from around the world, I was impressed with the likeness of the challenges we all face. From China, where only 12% of the elementary kids begin the last three years of high school, to Japan, where 100% begin high school and about 33% of their students start at the university, I saw concerns that were shared. How can we build a mathematics curriculum and support mathematics teaching that fit today's students and today's society? Allen Tarp from Denmark summarized my thoughts relevant to this conference with his three dreams. The dreams are paraphrased below:

Dream 1: Start from scratch and design a new curriculum.

Dream 2: Build that curriculum with problems that are real to students.

Dream 3: Re-engineer mathematics itself with a new generation of empowered students, bold teachers, enlightened educators, and innovative mathematicians.

Daniel J. Teague

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Sessions Attended

In addition to attending the opening and closing plenary sessions, I presented a paper in Working Group 13 on curriculum changes in secondary school, and participated in Topic Group 17 on mathematical modelling and applications. I also attended the ICMI sessions on gender and mathematics education and what is research in mathematics education? I attended the regular lectures on metaphors and models for conceptual change in mathematics, new pedagogy and new content--the case of statistics, and a decade of teaching mathematical modelling.

Working Group 13

The work in Working Group 13 centered on the changing secondary curriculum. On the first day, the working group split into two major groups, one group that focused on ages 12-16 and another that focused on ages 16-19. The organization of the group meetings was as follows:

Day	Ages 12-16	Ages 16-19
Tuesday	Algebra	Geometry
Wednesday	Geometry	Discrete
Friday	Discrete	Algebra
Saturday	General	General

I attended the Tuesday 12-16 algebra session, and the Wednesday, Friday, and Saturday 16-19 discrete, algebra, and general sessions. My paper was on utilizing precalculus experiences with graphing calculators--a local linearity approach to calculus, and was presented in the Friday, 16-19 algebra session and focused on the changes in the presentation of the principles of calculus made possible by students' experience with graphing calculators in earlier precalculus courses.

The presentations in the working group emphasized "realistic mathematics," that is, mathematical applications in realistic contexts and mathematical modeling. The presentations by educators from the United States, England, Australia, the Netherlands, and Spain all described changes in the secondary curriculum that revolved around what we call in the U.S. "real-world" mathematics. Only the presentation by participants from Iran had an emphasis on the theoretical aspects of mathematics. The changes in the secondary curriculum in Iran emphasized abstract combinatorics and number theory.

An important issue of the appropriate level of rigor in secondary mathematics was not adequately addressed in the working group. It was clearly a topic of interest, particularly in the light of the emphasis on applications in the presentations. What happens to theory and proof when the focus of instruction is on applications and modeling? Unfortunately, too little time remained after the presentations for an adequate discussion of the effect of the curriculum changes described by the presenters on the student's understanding of proof and the need for rigor. This could have been avoided, since most of the presenters had prepared papers ahead of time which were distributed to all of the participants. By having the participants read the papers ahead of time, the presenters could have led a discussion of the paper and used the limited time to more fully explore the ideas presented in the paper. The sessions would have been much improved if the presenters had given the major points of the paper as a means of initiating the discussion. More time should have been allocated for discussion than for presentation.

Topic Group 17

The work in Topic Group 17 focused primarily on curriculum projects that had a modeling flavor. While a lot of work has been done on developing good problem settings and successful curriculum based on modeling, little work has been done on assessment of these activities. Also in need of study are the issues of teacher development and the student's cognitive processes when modeling, as well as the metacognitive and affective aspects of effective modeling activities.

From the United States, the ARISE project was profiled, and an educator from China discussed their participation in COMAP's contest in mathematical modeling and the development of a similar program in China. Other projects from Brazil, Germany, and England were also presented, although they focused more on applications of mathematics than on mathematical modeling. Most of the presentations the second day focused on courses at the tertiary level for engineers and students of applied mathematics. I got several good problems to give to my students next year from these sessions.

What I Learned at ICME-8

ICME-8 was a tremendously valuable experience for me. I began discussions with colleagues from Japan and Australia about possible future projects. It gave me a chance to renew old friendships and meet colleagues, with whom I have been corresponding for several years, for the first time.

For anyone developing curriculum, it is essential to talk with others whose experiences and motivations are different from your own. It is particularly important to understand the positions of those who believe your fundamental principles are somewhat flawed and following them will result in poorer, not stronger, mathematics students. ICME-8 gave me the opportunity to have these important conversations. I received both positive and negative feedback on the ideas presented in my paper, both of which are helpful. ICME-8 offered many opportunities to talk with and learn from others who have similar interests. I hope they also were able to benefit from my experiences, both successful and unsuccessful.

The plenary talks, regular lectures, and ICMI studies sessions gave me much to think about. Looking through the notes taken at the conference, a number of specific comments and questions made during the sessions stand out in my mind.

- Will we use technology to explore mathematics or mathematics to exploit technology?
- Why is it that mathematicians value precision over clarity?
- Problem solving is a series of steps that transforms something you don't know how to solve into something that you do know how to solve. Problem solving ends when the problem becomes routine.
- Get funded! Don't try to change the system without money!
- Female students, more than male, feel the need to find the usefulness of mathematics, but they find school mathematics less useful than do the males.
- If technology is there for a purpose, girls will use it. If it's just a toy, boys will play with it.

- Mathematical meaning is constructed in the classroom through interaction. The structure of these interactions is closer to the practices that boys have in their culture than girls in theirs.
- Social constructivism takes a fallibility approach: the concepts, principles, and rules of mathematics were invented and evolved over time. This includes the rules of truth and proof. It rejects the existence of a unique, permanent foundation of knowledge.
- Given the student's freedom in society, the rigid approach and "led-by-the-hand" process of teaching is out of place. We must have more confidence in our students!
- Problems included on last year's exams become a secret curriculum for the following year.
- The 18th and 19th centuries saw manual labor replaced by technology. The 20th century is seeing intellectual labor being replaced by technology.
- Symbols represent both a process and a concept. Processes allow students to do math, but not to think about it. Students who see only the process have difficulty later on.

Finally, the experience of talking with mathematics educators from around the world at informal settings was equally valuable. I cherish the contacts and ideas gleaned from those informal sessions and appreciate NCTM and the arrangements committee's efforts to make this growth possible.

Therese A. Jones

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I. Sessions I Attended

I attended the opening session and exhibitions at the Casino de la Exposicion Sunday evening. It was a beautiful ceremony and the historical mathematical artifacts were fascinating. The official opening ceremony, held Monday morning, July 15, at the Seville Convention Center was well done. The two plenary lectures, Whither mathematics education? and On the role of the mathematicians in mathematics education, were interesting. They both touched commonality of the learning process and the importance of communication, that we as educators must work within the social/cultural/political context of our environment. The second, in Spanish, was well interpreted. That was not necessarily true in all cases. I am humbled by all the people at the Congress who were multilingual.

Most of the "Regular Lectures" I chose were those that discussed "mathematics education" in different countries. I listened to speakers from Russia, Japan, China, England, Spain, Switzerland and Australia, trying to get an understanding of common concerns, a common denominator of student needs, and a general idea of the various approaches that work in teaching mathematics.

II. Content of Working Group and Topic Group Sessions

I participated in Working Group 22 on mathematics, education, society, and culture. The facilitator was Richard Noss of the United Kingdom. The advisory panel was composed of Cyril Julie, South Africa; Jean Kantor, France; and Catherine Vistro-Yu, Philippines. The program was divided into three segments: social and political dimensions, cultures and criticism, and ideology and values. Each segment was scheduled to fill one day of the seminar, with individual talks and discussion held within a timed portion of that meeting. That method did manage to contain some complex topics within a framework that allowed all speakers a voice. It did discourage individual participation, since there was no small group discussions, no sharing other than response to a talk presented to enti[illegible] group.

I chose that working group because of my involvement in an intervention program. The Texas PreFreshman Engineering Program is an eight-week summer program directed toward underrepresented minorities in math and engineering. It focuses recruitment toward seventh through tenth grade students. I have directed the Amarillo area site of TexPREP for seven years. I wanted to learn about similar programs and how they approached the problems of coping with youngsters coming from diverse cultural backgrounds. That topic was addressed specifically in some of the discussions of the second day segment: cultures and criticism. Marta Civil from Arizona described her work with minorities (particularly Native Americans) and mathematics in Phoenix. An interesting study was presented by Kay Owens of Australia, based on her work with the Papua New Guinea people. This was my introduction to the concept of ethnomathematics, a term that was used frequently by the speakers of the third day: ideology and values. Different cultural groups develop distinct and rich mathematical systems just as they develop their languages. Using applications students see in their daily lives to build toward a more formal articulation of mathematical concepts helps them to appreciate the practical aspects of mathematics.

Ubi D'Ambrosio of Brazil gave the most impassioned speech about the social and political issues inherent in mathematics and mathematics educators. A consistent refrain of the ideological speakers was the reluctance of mathematicians to address mathematics reform. According to them, mathematics is historically exclusive, elitist, practiced only by a few, predominantly white males. One major cultural characteristic concerns the relationship between the individual and society. For example, in China the person is expected to adjust to society; in the UK, society strives to meet the needs of the individual. Such concepts do give insight in the approach to the diverse student backgrounds in my program.

I chose the Topic Group 4 on distance learning in mathematics because I am Co-PI of the Southwest Center for Advanced Technological Education (SCATE), funded by the NSF/ATE initiative. We are developing an interactive compressed TV system in the large rural area of southwest Texas and the Texas panhandle, eastern New Mexico, and the Oklahoma panhandle.

Distance learning is in the exploratory stage in this area; it was amazing to see how far behind the curve we are!

The distance learning group was organized by Haruo Murakami of Japan, with David Crowe of the UK and Nerida Ellerton of Australia on his advisory panel. Again, the design of the group was that of a talk and then some audience response, no small group discussion. The information shared is of real value to me and to the SCATE project. All the speakers are heavily involved in distance learning in their countries. All methods of distance education were discussed and demonstrated, including ITV, internet, video, CD-ROM, computer software, radio and television; even "snail mail" was addressed. The range of distance learning is amazing; the various systems are scheduled from within the same town—even building—to across continents. Successful and unsuccessful experiments were described. Four themes threaded the topic group presentations:

1. A sharing and celebration of personal experiences in distance teaching of mathematics;
2. A glimpse of the structure of current distance courses in mathematics;
3. A glimpse of the content of current distance courses in mathematics;
4. Challenges to educational and philosophical assumptions underlying the above.

This was a very interesting and useful topic group.

III. What I Learned at ICME-8

I learned that teachers of mathematics all over the world share a concern for their students, for their discipline, and for their ability to become better teachers (or just to maintain status quo!) in a world of change. I did not see the arrogance and elitism that Ubi D'Ambrosio and his social justice colleagues charged the mathematical community with. Perhaps the fact that ICME is a force of mathematics educators rather than mathematicians made that difference.

Technology is seen as the driving force for change, not just in terms of calculators and computers, but in many ways. Ease of communication, travel, information exchange, entertainment, culture shock...technology is there. In industry, in commerce, and in service-oriented professions, technology has a heavy influence.

The reevaluation of the human/technological relationship impacts the teaching of mathematics. The inherent underpinning of mathematics in a technology world does nothing to make it more visible. How can we as teachers make mathematics meaningful to our students? Do we revert to presenting traditional content? Do we collapse into process and not concern ourselves about content? Do we focus on the abstract? Or do we try to broaden mathematics and make the invisible mathematics more visible in our day to day lives?

I attended two valuable sessions Saturday afternoon; the first, a sharing session for Two-Year and Technical Colleges was sponsored by the American Mathematical Association of Two Year Colleges. It was attended primarily by people who taught at those institutions, but also by math educators that simply wanted to learn more about a rather special concept. The meeting was successful; as a community college faculty, I hope ICME-9 will offer and publicize another such session in year 2000.

The second, attended by the most participants of any lecture that I saw, other than the first-day plenary lectures, was the session on What is research in mathematics and what are its results? Jeremy Kilpatrick led a panel in the "critique" of a study in the early stages of publication by leaders of ICMI. It seemed to me the session could best be described by a quote offered by one of the audience, "Mathematics education is really more complicated than you expected it to be even though you expected it to be more complex than you expected." It was the best example of the entire week of how diverse ICME really is.

As is usually true of congresses, the most valuable result is the contact with fellow teachers, particularly teachers of mathematics. The emphasis on how to teach mathematics as well as examples of how it is taught, was wonderful. I came away from Seville enthused and renewed in my love and appreciation of mathematics and my vocation of teaching.

Donna M. Simpson

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Flossmoor, Illinois

I. Sessions I Attended

While at ICME-8, my primary focus was on technology in math education, assessment practices, and equity issues in the field of mathematics. With this in mind, I participated in Working Group 15 on the impact of technology on the mathematics curriculum and Topic Group 18 on the role of calculators in the classroom. Based on these interests, I selected regular lectures that kept with the theme of my trip—math education and gender issues, issues in assessment--a never ending story, and teach kids for their future, not our past. Also, as a supervisor of teachers of mathematics, I attended a regular lecture on some considerations on problems and perspectives in mathematics teacher inservice education. In addition to sessions and lectures based on specific interests, I also attended the plenary sessions on Whither mathematics education? and on the role of the mathematician in mathematics education, and the poster sessions and exhibits.

II. Content of the Working Group and Topic Group Sessions

As a supervisor of mathematics teachers and a classroom teacher myself, I am truly concerned about how and what we are teaching our children. My concern, it appears, is shared by many others across the world. This became evident in the two groups in which I participated for the week: Working Group 15 on the impact of technology on the mathematics curriculum and Topic Group 18 on the role of calculators in the classroom. Although at first glance, it may appear that these two groups would have similar content, in actuality, the topics of conversation were very different. In the working group, the focus was truly on the actual effect technology is having and will have on the mathematics curriculum as we know it today. While the working group focused primarily on effect, the topic group turned its attention to how to actually use various calculators and other technology in math classes at all levels.

Working Group 15 opened with an overview of the mathematics curriculum in the technological era. During this opening session, the presenters referred to previous changes in mathematics curriculum that involve organizing around the "big idea" as "new bottles, old wine." This idea centered around taking present curriculum and presenting it in a different manner. The new changes we face, though, were referred to as "new bottles, new wine." The content of this opening talk focused on adapting present curriculum to fit the changing society. Once the curriculum has been adapted, the presentation of that curriculum through the use of technology and how it would affect students, teachers, community and any others involved in the schooling of children was to be the topic of the group for the week. After the opening session, a series of paper presentations was given. As a part of subgroup 2 on organizing curriculum around big ideas, I was able to participate in presentations by Patrick Thompson of San Diego State University (Technology and curriculum reform: Designing curricula, instruction, and technology-enriched learning to meet where none of them is); Kathleen Heid of the Pennsylvania State University (Reflections on technology-intensive efforts to restructure algebraic experiences around functions and mathematical modeling: The roles of mathematical thinking and understanding student understanding); Michal Yerushalmy of Haifa University in Israel (What has to be visible? About transparency of mathematical concepts and transparency in software design); Sharon Dugdale of the University of California-Davis (Technology as both driver and supporter of curricular change in mathematics: Merging multiple roles); and Rolf Biehler of the Institut für Didaktik der Mathematik at Universitat Bielefeld in Germany (Functional and statistical relationships: Using technology to relate deterministic and stochastic thinking in the mathematics curriculum). Also, I had the opportunity to participate in the roundtable session lead by Patricia Tinto of Syracuse University on transitioning from traditional settings to inquiry communities and the role of technology. On the final day of the working group, we were treated with a sample of various software demonstrations from the United States, the United Kingdom, the Netherlands, and Israel.

While the working group focused mainly on the actual impact of technology, Topic Group 18 offered a look at how mathematicians all across the world are using various types of calculators in the process of transmitting knowledge to students. Each of the two days began with a plenary talk followed by a series of short talks. The speakers ranged from Bert Waits of The Ohio State

University to Shin Watanabe of Tokai University in Japan. The content of all of the talks during this topic group was how calculators are used in the classroom to aid students in modeling and real life applications. In addition to countries such as the United States and Japan, Pedro Gomez spoke to the group about the use of graphing calculators in underdeveloped countries. Another topic that arose was the issue of why integrate calculators in the classroom. Some of the participants questioned the need to add calculators to classrooms that they felt were already working.

III. What I Learned at ICME-8

In terms of relevance to the teaching and learning of mathematics, the experience of an International Congress on Mathematical Education is by far one of the best ways to gain a global perspective on math education. Inclusive in that thought is the idea that each individual school is simply a small segment of a far reaching society of educators who share many of the same problems, hopes, and possible solutions. The number one idea that I was able to take away from the congress is the concept of teaching students for a future that is a complete unknown to us today. This idea could be summed up in the title of one of the regular lectures I attended, presented by Douglas Brumbaugh, teach kids for their future, not our past. Throughout the course of the week, math educators from around the world seemed to grapple with this concept as we all felt the impact of a changing world.

The major changes that we are faced with in the future are technology, assessment issues, and equity for all students. In terms of technology, I was simply amazed at how many mathematicians from all over the world are using the same types of technology. While sitting in the working and topic groups that involved technology, presentations were made that involved graphing calculators by Texas Instruments and Casio from people all over the world. Not only do we here in the United States see the benefits of deeper thinking and problem solving skills that the calculator offers, but so do math teachers in England, Austria, Mexico, Venezuela, Japan, Portugal, and Spain, to name a few. Collette Laborde of Grenoble, France, did a presentation of the use of the TI-92 in the classroom that summed up for most of us where we are all trying to head with the technology. She emphasized that with new tools, we are faced with new phenomena that will in turn generate new questions. Globally, we are trying to help students learn, through the use of technology, how to produce, predict and explain. Along with the technology, though, comes a number of universal questions: Are we inserting technology simply for the sake of technology? Are we throwing out the theoretical mathematics? Are we no longer teaching students to truly think? In the five days of this congress, we could not possibly answer these and many other questions surrounding the inclusion of technology in the curriculum. However, it showed that all over the world, we are faced with this issue of technology and are proceeding in a cautious manner. The other question that arises for many of us is the cost of the technology and the non-monetary cost of the caution with which we proceed.

A second important issue from the conference is that of assessment of students. Be it in Australia or Japan, the way that teachers assess students is changing. There seems to be agreement that the traditional paper and pencil test needs to be supplemented with real life activities. In some cases, those supplements took the form of technology, while in other cases they took the form of projects. The one idea that came out of a talk by Paulo Abrantes of the Universidade de Lisbon in Portugal is that assessment needs to have genuine and immediate relevance for children. These activities need to be purposeful and meaningful while offering students some interaction and reflection in the process of learning mathematics. Hearing someone from Portugal say the same things that we say, here in the United States, about assessment is truly refreshing. It has lead me to believe that these pockets we make for ourselves in this country are simply squares of the same global quilt.

Finally, the idea of equity issues in mathematics permeates our society as well as many others. Gilah Leder of Australia gave a talk on gender issues in mathematics education that detailed studies done in their country about minorities and women in mathematics. This same issue exists in the United States and every other country that educates more than a privileged few. The idea of how to make math accessible to all students is a topic that the world community must address in order to help countries develop some guidelines on this issue of equity. From the congress, it became apparent that many countries are dealing with this issue; however, no one seemed to be able to offer a solution, only statistics.

Overall, my experience at ICME-8 was very enlightening. For the first time in my mathematical career, I was able to see how my school, my staff, and I, as a fellow mathematician, fit into this larger scope of education. Upon my arrival in Spain, I had no idea that I would find so many others like myself who spoke so many other languages. I was also amazed to find out, for the first time, that the United States does not have a patent on the use of technology in the classroom. In many countries that are not nearly as developed as the U.S., teachers are doing more with technology in class and receiving support from the government. On my way home, I reflected on how we view education in the U.S. and wondered how we will keep up, much less stay ahead, with all of the changes on our horizon. This is indeed an exciting time in the field of math education, not just in the U.S. but in the entire world. As we all face the coming of a new century, we all want to be a part of a changing math education.

SAME QUESTIONS/DIFFERENT ANSWERS

Linda P. Rosen

National Council of Teachers of Mathematics

Reston, Virginia

I. Sessions I Attended

There were two striking aspects of ICME-8 that cut across language and cultural barriers. The first was the commonality of questions being asked by mathematics educators worldwide; the second was the diversity of their responses to the questions. This diversity was both humbling and enlightening as lectures, working and topic groups, and impromptu conversations led participants to reconsider what they might have previously held as axiomatic in mathematics education. Answers varied to questions such as: What are the central concepts in mathematics that are worth learning? What is known about students' modes of learning? What is the best method of implementing large-scale educational change? Whether the answers to these questions applied to one's own circumstances was not the critical issue. Instead, it was the recognition that one's usual array of answers could be enriched considerably.

My interest in curriculum issues guided my working group and lecture choices, including: the changing face of school algebra, mathematics education and gender issues, new pedagogy and new content--the case of statistics, and accounting for mathematical learning in the social context of the classroom, among others.

II. Content of the Working Group and Topic Group Sessions

Working Group 11 had the title a curriculum from scratch (zero-based). The underlying premise was that a curriculum based on reasoned analysis rather than on tradition provides the best lever for fundamental change. Hugh Burkhardt (U.K.) noted the magnitude of the challenge of implementing curricular changes: 10^6 is the number of teachers of mathematics in the United States; 10^5 is the number of lead teachers in schools; 10^4 represents the number of district trainers and teacher educators; 10^3 is the number of mathematics education "activists" in the United States; 10^2

is the number of people involved in creating curricular frameworks and curriculum; 10^1 represents the number of high level policy decision-makers; and last, but certainly not least, 10^0 represents each individual with skills and their own personal agenda. Burkhardt suggested the following list of issues that must be addressed: How much change is needed? How much can be tolerated? How fast can it be made? What kind of change is needed, e.g. content, process, classroom interaction, types of tasks, ways of working together? What are the pressures? The support systems? What are the resources? Business as usual—a traditional curriculum—was clearly not the answer for Burkhardt.

Several aspects of curricular change were described. Frank Demana (U.S.) observed, for example, that given the goal of total inclusion of technology in the curriculum, seed money is important but insufficient. He said that the potential of technology will only be realized when significant financial support is made available—requiring, in all likelihood, the diversion of monies from other educational programs to technology. Len Sparron (Australia), presenting on behalf of Alistair McIntosh, described societal aspirations for school mathematics and how these aspirations affect the need for competence in written computation. McIntosh argued, for example, that the adult population has little need for written computation: such work is rarely reliable, it is often redundant, and it does not lead to better mathematical understanding. Instead, he recommended a "number sense classroom," where the emphasis is on mental computation and calculator competence skills that will be more useful to students later.

Susie Groves (Australia) argued that the inclusion of any topic in the curriculum needs to be justified on its own merit. She described her research on how calculators can be used in the lower primary grades. In particular, she found that with calculators, there were more open-ended exploratory activities planned, more opportunities for sustained independent activity, and more opportunities for children to share their own work. A Danish participant noted that children will not learn the standard algorithms unless they believe that it will make their work "easier." Alan Bloomfield (England) and Susan Sanders (Wales) described their work in pre-service education to prepare tomorrow's teachers for an innovative curriculum. Bloomfield suggested that teacher educators must become more proactive in their roles by: (1) having experienced teachers serve as mentors to novices; (2) encouraging all teachers to be critical of any curriculum; (3) fostering self-reflection, especially among novices; and (4) raising the status of teachers. Bloomfield and Sanders raised several questions to consider in reflecting on the roles of teacher educators: How do teachers become learned teachers? Is the process best accomplished through central control or through teacher autonomy? What is the appropriate relationship between teachers and researchers? Although the answers to this questions were still inconclusive, they provided a framework for a lively exchange of ideas.

The working group session ended with the agreement that a major change in the school mathematics curriculum was necessary. Karen Usiskin (U.S.) suggested several criteria on which to base curriculum decisions: (1) Is there a real-world need? (2) What is the time needed to teach the idea to most students? (3) How does learning this topic pay off for learning in subsequent courses? (4) Does the topic have "beauty" for most students? and (5) What is the synergy between the topic and the pedagogy? Left open for future discussion are ideas such as the role of drill and practice in and the development of a philosophy and implementation plan for a zero-based curriculum.

Topic Group 20 had the title technology for visual representation. This group looked at the effect of fast, sophisticated technology on mathematics education. Of particular interest was the impact that the visualization capability of increasingly powerful technology would have on teaching and learning. Several questions framed the discussion: (1) Does visual representation play the same role in all aspects of mathematics learning? (2) Will work with technology enhance mental imagery or cause it to atrophy? (3) In dynamic computer environments, will pupils learn different mathematics? (4) What is the role of the teacher in orchestrating new technologies? The group also discussed a challenge inherent to research on the use of technology in education; the lag time between the "doing" and the "reporting" of research often covers at least one new generation of equipment. Hence, the visualization capability of the research equipment was significantly less than the capability of what had or would soon emerge, skewing the applicability of reported results for use by students. Further complicating the issue is the difficulty in getting powerful equipment in classrooms. Consequently, the research was interesting in an esoteric sense more than in a practical sense.

A striking omission among the presentations and discussion was the lack of acknowledgment of visualization through technology other than computers. No mention was made of video, film, or even visualization using paper and pencil. This arena will likely be explored at subsequent meetings as the decreasing costs make powerful equipment more readily available.

III. What I Learned at ICME-8

Underlying much of the discussion at ICME-8 was a question that goes to the heart of U.S. reform efforts: How can we teach significant mathematics to more students? Carolyn Kieran (Canada), speaking to what should be included in "significant mathematics," noted that research does not support the idea that a focus on understanding leads to "facility" with symbolic manipulation. Nonetheless, she noted there is a widening view that school algebra should focus more on algebraic thinking than on symbol manipulation. In particular, she noted that the use of computer technology provided other means of representing relationships than through traditional equations or letter symbolism.

Gilah Leder's (Australia) presentation focused on a different aspect of the underlying question--reaching all students, particularly females, with significant mathematics. She cited three major obstacles to this goal. First, mathematics is often presented as a "womanless" discipline, strongly dominated by males. Second, those few women who do "make it" in mathematics are presented as such special cases as not to be plausible role models for most young girls. Third, far too many believe that females need special help to be high achievers in mathematics. Leder ended with some optimism, however, noting that a shift was underway in these attitudes.

Kath Hart (UK) spoke of the responsibilities that researchers have to teachers and students. Current themes of reform were woven throughout her comments. She said, for example, that there was no evidence that children developed formalism from work with concrete manipulatives. She continued, noting that students could not reinvent concrete models when the abstract ideas were not understood. Most of all, she emphasized the need for research to help teachers improve their teaching and learning. In particular, she urged teacher trainers to: (1) make mathematics more attractive; (2) follow teaching strategies that break the cycle of teacher explains--checks understanding--explains again; and (3) generalize research results to theory.

As the NCTM Executive Director, I also had the opportunity to enjoy conversations with international colleagues at the NCTM exhibit. Many showed significant interest in the Council's publications and in the U.S. effort to implement standards-based mathematics education. Clearly, attendees at ICME-8 valued the opportunity to exchange ideas and to stimulate their own thinking for at least the next four years until ICME-9.

Marilyn E. Mays

North Lake College
Irving, Texas

I. Sessions I Attended

The organizers and staff for ICME-8, both the professionals and the students, could not have been more gracious. Many student helpers were proficient in English, and even those who spoke almost no English would valiantly try to assist with any problem we encountered. The organization appeared to be well thought out. There was a good balance of academic sessions and social activities.

I attended all of the opening day's sessions which were presented in the conference center under less than optimum conditions. The quality of the amplification seemed to be inadequate and the translation, though at times adequate, was unsatisfactory for some of the program. The overheads used by the presenters were readable only from the front of the room. While a rousing presenter in either language would have made an effective kickoff for the conference, a day of listening to speakers, alone and in groups, was not appropriate for a meeting of the size and diversity of attendees, particularly when the lecture method is something for which we are being urged to find alternatives.

I began the week attending Working Group 15 on the impact of technology on the mathematics curriculum. Later I attended Sol Garfunkel's presentation on applications reform--a brief history in time. Wednesday the two lectures I selected were important cognitive changes in the learning of mathematics--a developmental perspective and new pedagogy and new content--the case of statistics.

On Friday, I changed to Working Group 17 on mathematics as a service subject at the tertiary level. I also attended issues in assessment--a never ending story. The topic groups had their first sessions on Friday afternoon. I was on the Advisory Panel for Topic Group 5 on education for mathematics in the working place and made a presentation in this group.

On Saturday, I attended the last session of the working group and assisted with the topic group. In the evening I chaired the sharing session for two-year and technical colleges which AMATYC sponsored.

II. Content of the Working Group and Topic Group Sessions

The working group I first attended covered many of the issues that have been discussed at length at many conferences in the U.S. I began the week attending Working Group 15 on the impact of technology on the mathematics curriculum. I was supposed to attend another working group but it was cancelled. I chose Working Group 15 because it was in the same building where the cancelled working group was supposed to be. Due to a very late bus from my hotel which was at a considerable distance from the university, and also to the fact that I had wasted so much time looking for the first one, I didn't want to waste any more time trying to find something in another building.

Working Group 15 was very large, probably 300 or more. Not surprisingly, there were many who voiced concerns about students losing the ability to calculate without technology and about technology driving the curriculum. The size of the group of people who had selected this topic made discussion difficult. On Friday I changed to Working Group 17 which was a more satisfactory situation. They had broken down into three groups and the one I attended had about a dozen people.

The group discussed the difficulty that mathematicians have in getting faculty in other disciplines to articulate the mathematics that their disciplines require. One method of securing the information is to explore mathematics texts written by faculty in those other disciplines or to survey the texts for the courses taught in the service area. Dialogue with a group of faculty from other disciplines and a group of mathematicians is often an appropriate vehicle for obtaining the desired information.

The subset of the working group also discussed the desire of some faculty in other disciplines to get their students through the mathematics as quickly as possible with nothing more than rudimentary knowledge of the principles. Some even counsel their students against taking any math where it is not required for their program.

Several stated their belief that some faculty would prefer that students be taught formula tricks rather than basic understanding of mathematics fundamentals. For example, they might demonstrate the manipulation of the formula $T=PV$ by a circle with the horizontal diameter drawn as well as a vertical line bisecting the bottom half of the circle. A T is placed in the top half circle and a P and a V in each bottom quarter-circle. This tells the student that $T = P \times V$ and that T divided by either P or V yields the other letter.

Group attendees discussed ways to make courses broad enough that students from more than one discipline can take the course and so that students who take the course are prepared for changes in that career or to change careers.

III. What I Learned at ICME-8

At both of the international congresses that I have attended, ICME-7 and ICME-8, I have been impressed by two things: (1) The problems we face are fairly universal; and (2) Those who have a background in mathematics who are teaching mathematics in technical colleges and for workforce development seem very interested in making the mathematics appropriate for these students, while at the same time teaching the fundamentals of mathematics which will prepare students for changing circumstances and demands of their jobs or for changing careers. It appears that the problem of technical mathematics being taught by people who do not have sufficient background in mathematics is also one common to many countries other than the U.S.

Over 30 people attended the session on Saturday evening for those interested in mathematics at two-year and technical colleges. They were very interested in encouraging the leadership of ICME-9 to offer something for this segment of the mathematics community.

Some of the points raised at this meeting echoed those heard at the topic group sessions.

- It is difficult to have an authentic workplace situation in the classroom and even more difficult to have authentic assessment in the classroom.

- We see the math differently from our students. They see specific uses--we see general principles. Non-math faculty who teach mathematics often teach specific uses rather than general principles; students need the more general education to build their knowledge on and to make transitions.

Cheryl S. Cleaves

State Technical Institute at Memphis

Memphis, Tennessee

I. Sessions I Attended

The Art and Mathematics Exhibition on Sunday evening was exciting. The many early manuscripts were impressive and interesting. The official opening ceremony on Monday gave hosting officials an opportunity to welcome participants from around the world and to share some of the concerns and hopes for mathematics education. The working and topic groups were interesting. The groups I attended were more lecture and less "sharing." The sessions were interesting and some good ideas were presented. The mathematics in the first two years of college which Marilyn Mays facilitated on Saturday evening, July 20, was excellent. This session was well attended by interested mathematicians from many countries. A strong desire was expressed to have a strand of presentations especially for the first two years of college ICME-9 in Japan.

II. Content of the Working Group and Topic Group Sessions

I attended Working Group 18 on adults returning to mathematics education. One presenter gave a report of research on the topic. She offered several suggestions for helping adult students analyze their learning status and communicate it to others. For example, the student could be prompted to think, "I was OK until I got to ___." This would enable the student to organize what he or she knows and understands so that instruction can begin at that point. This speaker also emphasized the importance of helping students actively create and maintain a support system for their learning by gaining the support of significant others such as spouses, family and friends.

Students should understand that much of mathematics is "invisible mathematics." This invisible process is the many processes that go on in the brain to process mathematical information and only a small portion of this thought is translated to paper.

Another speaker in this working group had very poor graphics and was difficult to understand. This presentation took an "ethno" mathematics approach. It was noted that Brazil has an 18% literacy rate. However, it was unclear what base was used to make this calculation.

101

Kathy Stafford from Rutgers discussed the NCTM Standards and emphasized the use of calculators similar to the way they are used in the workplace. She noted that adults are "present-oriented" and bring much information to class. They also can bring problems from their workplace or home to class and present them to the class for everybody to work on. Students should have an opportunity to apply mathematical content more immediately. For example, mortgages and car loans can be used when studying formulas, exponents, etc. She offered several insights to characteristics of teachers who emphasize the teaching aspect of the learning relationship. Teachers should listen; they should not finish students' sentences. Rather, they should give students time to think; this sometimes requires wait time. Teachers must move from the role of "teacher" to "facilitator."

III. What I Learned at ICME-8

My experience at this, my first ICME, was very positive. It was exceptionally interesting to talk with educators from many other countries. I learned they have many of the same concerns that have been expressed in the U.S. about mathematics education. Students the world over have math anxiety. Students tend to avoid mathematics and many drop out of school much earlier than in the U.S. This seemed particularly so for developing countries.

Technology is increasing in importance as a tool in teaching mathematics. Most educational systems are concerned with funding and pupil/teacher ratio. However, I left the congress with the feeling that there are many dedicated mathematics educators worldwide and that we all enthusiastically continue to seek solutions to the challenges we face in a world in which communication technology is increasing exponentially. I made many new professional friends and, because of technology, will be able to communicate with them about issues and concerns we commonly hold.

This NCTM program, funded by the National Science Foundation, is very important to increasing understanding among world cultures. In addition to making presentations to my colleagues at my home institution, I am scheduled to discuss this experience at the AMATYC conference in Long Beach this November.

Raymond P. Guzman

Pasadena City College
Pasadena, California

I. Sessions Attended

I attended the following sessions: Working Group 10 on languages and mathematics; Topic Group 11 on the future of calculus; four plenary sessions: Anna Sierpinska on Whither mathematics education?, Miguel de Guzman on the role of the mathematician in mathematics education, David Tall on information technology and mathematics education--enthusiasms, possibilities and realities, and Jan de Lange on real problems with real world mathematics; regular lectures by Changpei Wang on mathematics education--an Oriental point of view, Siegbert Schmidt on semantic structures of word problems--mediators between mathematical structures and cognitive structures of the students, Gilah Leder on mathematics education and gender issues, David Moore on new pedagogy and new content--the case of statistics, and Geoffrey Howson on mathematics and common sense. I also attended a special session organized by David Tall in memory of Prof. Richard R. Skemp.

II. Content of the Working Group (A) and Topic Group (B) Sessions

A. Patricio Herbst spoke on metaphor in mathematical discourse, Newton's metaphor of movement, analogies with moving bodies, the issue of rigor, Max Black's three ideas of metaphor, and metaphor as a site for the production of meaning. Joop van Dormolen spoke on levels of language and compared ways his students explain to others using active (constructive) language, which explains math as a process, and descriptive language, in which the only verb used is a form of "to be." Students use language at the level of other students' understanding. The teacher must be aware of the level that works for the class, helping students to move up from active to descriptive language as they learn. Rosalyn Hyde spoke on using geometric patterns and integrating language and geometry. She explained her research with three pairs of students of various abilities, one in each pair describing verbally to the other what to do (no pictures allowed), in order to draw complex geometric shapes. She taped the descriptions and analyzed types of words used for each. Successful descriptions start with a global description, then give more details. Her students used metaphors—"it's like a ...," and lots of active words. Phyllis August-Rothman spoke on a definite maybe, stressing abstraction vs. extraction (getting rid of the superfluous). She discussed associative thinking (two words may be related in form and in meaning, as in several examples using Arabic, Latin, and Chinese). By “definite maybe” she refers to Polish mathematician Lukasiewicz who gave the value of 1/2 in a truth table to the possibility of “maybe,” as well as 0 for “no” and 1 for “yes.” She illustrated the disjunctive “or,” the conjunctive “and” and equivalence, discussed differences between English and other languages, and discussed the linguistics behind the if-then idea and the lack in Chinese of hypothetical constructions and tenses. Adam Vile discussed the ideas of sign, interpretant, and object, and the semiotics of mathematics, according to Peirce. Jose Quesada spoke on the connection between language and mathematics, artificial intelligence, and getting students to understand and use correct language in doing mathematics. Dhamma Colwell spoke on teaching math to adult speakers of other languages, for whom English is the 2nd or 3rd language and the importance of social, cultural, political, and educational backgrounds and the transfer of mathematical knowledge from one language to another. Students from her research feel weak in writing at the academic level. Jean Lave's work was cited: all learning takes place in a culture and community. To move from apprentice to master, one needs language as well as just the nuts and bolts or else one will remain on the periphery. Bill Atweh spoke on sociolinguistics and mathematics, the interactions of gender and socioeconomic factors, and the concepts of field, tenor, and mode as elements of context in teaching mathematics. On the last day we discussed cognitive aspects of languages and communication, use of language in learning, teaching, reasoning and thinking, the revolution in language theories in this century, conceptual structures, different levels of knowledge, laws of thought, and math as a representation of the world and as an activity, and how we make real, for our classes, the results of all this theory. Math teachers should distinguish common sense language and mathematical language (a meta-language), as often students cannot. Students do not hear in the same language as we speak. There is more difficulty if what is spoken in meta-language is English, but the class is non-native English speaking.

B. Paul Zorn of St. Olaf's College discussed calculus reform in the U.S.A., the 1986-94 NSF supported reform projects, and the new texts that began to appear in 1992 (Harvard Calculus, Project Calculus, Oustegee, and Zorn's own text). He discussed the importance of graphical, numerical, and symbolic representations all together (not just symbolic representations) of calculus, less formal proof in the classroom, but more concepts, modeling, applications and varied problems. He backed up his ideas with examples in graphical representation and in numerical representation, which the group discussed. He noted the value of technical equipment (calculators and computers), to do graphs accurately and quickly. We discussed the role of technology, the role of algebra in calculus, pure vs. applied mathematics, constructivist theories, assessment when students have TI-92's, and our students' majors. The role of algebra will continue strong, but change, for example, to emphasize parameters.

III. What I Learned at ICME-8

I learned that math may be an "abstract language" for some of us; but it really, for most, is part of everyday life. We should embed our teaching into real life situations and make use of what students already know. I learned from Anna Sierpinska's talk that it is difficult to devise an indirect rather than direct didactic approach to teaching mathematics. Some indirect examples are distance, rate, time problems, and teaching vector spaces in linear algebra using models of lines and planes. I learned of Rothman's idea of "interactionism" and of Sierpinska's research in Toronto on the benefit of the teacher considering, rather than dismissing, student answers, and following up by asking "Are you sure?" to get the student to explain further. We should stress activities which integrate algebra, geometry, etc. and use the link between mathematics and communication, stressing language in the math class and giving students the opportunity to speak. From Miguel de Guzman, I learned of the need to stress math as a key to understanding the universe and to transmit to society the advancements math has made to help society and to advance culture. We need to share a personal view, make our recipients share our vision, and be enthusiastic about our field. In the USA many groups, such as the NCTM, are pushing for changes in math education, and the mathematician needs to intervene in reform groups to be sure sound changes are made. From Gilda Leder's talk on gender equity I learned of the contributions in education theory and psychology of Lita Hollingworth, who championed the cause of gifted girls, and Karen Horney, who contributed to thoughts on equality of women in education. Significant differences are not observed until higher level mathematics, and are partly due to texts which picture males doing math and activities that males like, and to more encouragement being given in class to boys. Boys do better in mathematics that is contextualized to areas that interest them. What does help girls are the intervention programs to encourage them to select the right studies. We should present women and their interests as central to mathematics. From Geoffrey Howson's talk I learned how important it is to stress that math is grounded in common sense. When students learn to multiply negative numbers, the link between common sense and math begins to break down. Certain somewhat abstract topics have become today's common sense, or "local knowledge," such as scientific notation, often due to being mentioned via newspapers, T.V., and playing with calculators. From David Tall's speech, I learned how the computer, the internet, and graphing calculators give humans the enthusiasm to do more creative mathematics. Multi media and computer software aid much in visualizations of statistical ideas. Computers are useful for symbolic manipulation. It's essential that students be able to think about what they are doing. From Wang Chang Pei's talk, I learned of the recent upgrading in math education programs in China. The new principle there is that math education is for all. I saw an interesting video of an algebra classroom learning the terminology of "a to the nth power," i.e., base, factor, exponent, etc. The teacher has the class explain the use of laws of exponents, clarifying the interaction of base and factor and exponent. I found the use of English symbols in China to be very interesting and gained insight into the Chinese system of math education. I also got a lot of insight into how students and teachers interact in the classroom in China (this relates greatly to how my many students from China have learned math). The belief and value systems in Chinese education are becoming changed (Westernized). Nevertheless, one of the main objectives, according to the speaker, is to develop in Chinese students a belief and world view of dialectical materialism. The speaker enlightened me as to certain differences in Chinese and English languages, and how these differences impact on Chinese students. Most important were the lack of nominative and objective cases in Chinese, the lack in Chinese of the construction "if A does not have property P, then ...," which gives difficulty to Chinese speakers in an English speaking classroom (Chinese may object that the phrase following the if is not true, hence the whole statement is without value). Also, the Chinese students have difficulty with converse, inverse, and contrapositive, and it is necessary for the teacher to be aware of this situation so as to help students having difficulty with language and word problems.

Margie J. Hobbs

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Memphis, Tennessee

I. Sessions I Attended

The Sunday evening activities were impressive. It was exciting to see the manuscripts and early works of mathematicians whose work I had studied and taught. The exhibit on tools was also very interesting. While not a direct part of the conference, the city of Seville offered many excellent examples of geometric designs which I was able to capture and will use in my classes. The opening ceremony on Monday, which included the Mayor of Seville and other dignitaries, was very interesting. Since this was the first international congress I had attended, I was very interested in the way communication in two languages was handled. For the opening session, this was very effective. The working groups were interesting. However, I had thought the working groups would be more interactive. Even so, I gained some new ideas for improving student learning. The regular sessions ranged from excellent to ordinary. Sol Garfunkel's session on the development of projects drew the interest of many attendees. "Projects" was also the theme for the session on project work as a component of mathematics curriculum. The presenter gave us an overview of his philosophy and gave us some useful tips on implementing student projects. He gave these characteristics of project work. The work should be intentional. It should promote autonomy and responsibility. The project should be authentic and should encompass complexity and uncertainty. "A project integrates conception and execution—two different aspects that find their unity through the author or authors of the project." Projects should be balanced with other class requirements and should be practical in the perception of the student. Projects also help the student learn negotiation as suggestions for projects may come from the student or teacher and the two negotiate to arrive at a mutually acceptable "chunk of work." Projects should include a balance between theory and practice, individual and collective efforts, and success and failure.

One of the most rewarding and helpful sessions for me was the Saturday evening session facilitated by Marilyn Mays, former president of AMATYC. The purpose of this session was to create a forum for discussion of mathematics that is taught in the first two years of college. Many mathematicians from a large number of countries attended this session and an excellent discussion ensued. One consensus of the group was to recommend that a strand for the first two years of college be established for the ICME-9 in Japan. It was felt that this would enable this group of mathematicians to do further work on similar concerns.

II. Content of the Working Group and Topic Group Sessions

I attended Working Group 18 on adults returning to mathematics education. The speakers in these sessions offered some interesting ideas for working with adults who are returning to school or college to study mathematics. First, they are different from "traditional" students in that they are often disenfranchised by the educational systems in their counties. They often have special reasons for returning to college and need to establish a strong support system for their success. One speaker addressed the issues such as helping these students understand their mathematical thinking process. Another speaker stressed the difference in pedagogy and "andragogy." Some characteristics of adults include being reluctant to ask for help, looking at answers and thinking they understand the mathematics, and saying they know when they don't. Teachers must be sensitive to these adult tactics and find ways to enable students to know what they know and to ask about what they don't know.

III. What I Learned at ICME-8

ICME-8 was very exciting. This is the first international mathematics congress I have attended—an experience I never dreamed I would have! Discussing important issues with mathematicians from many countries in the world was extremely gratifying. The most important thing I learned was that people are people. And people have the same learning patterns throughout the world. Some cultures have values and ways of doing which may promote the learning of mathematics. However, I found that educators have many similar problems and challenges. Students in all countries tend to avoid mathematics. Some students lack motivation to study mathematics. However, among the individuals with whom I worked and visited, I found a theme of optimism and accepted challenge for improving the learning of mathematics.

I am very grateful to have had an opportunity to learn and share. I will be making a presentation about this experience at AMATYC in Long Beach in addition to sharing informally with many mathematics educators.

Jacek Kostyrko

Kenai Peninsula College

Soldotna, Alaska

(currently at San Joaquin Delta College)

I. Sessions I Attended

I attended the opening plenary lecture by Anna Sierpinska on Whither mathematics education?.

I divided my attention between two working groups: Working Group 10 on languages and mathematics and Working Group 21 on the teaching of mathematics in different cultures. Also, I attended one session of Topic Group 11 on the future of calculus.

I attended the following regular lectures:

Adrien Douady: Seeing and reasoning in parameter spaces
Gilah Leder: Mathematics education and gender issues
Juliana Szendrei: The role of mother tongue in mathematics learning

I participated in one Workshop (mathematics of chaos) and the sharing session for Two-Year and Technical Colleges.

Finally, I attended several short presentations (videos, posters, software, project reports) and a number of exhibits at the congress.

II. Content of the Working Group and Topic Group Sessions

1. Working Group 10: Mathematics and languages

This group focused its attention on the role of languages in mathematics and mathematics education. It tried to explore the position of mathematics in the philosophical triangle World—Mind—Language. The main assumption of the discussion was that the language we use fixes the limits of our communication, and probably also the limits of our knowledge.

The presentations varied from purely academic to down-to-earth and practical. The two presentations that I found particularly interesting were by Phyllis August-Rothman on a definite

111

maybe and Rosalyn Hyde on mathematics and language--a study of children describing geometric patterns.

The first talk, rich in examples from languages as diverse as English, Italian, French and Spanish on the one hand, and Chinese, Hebrew and Amharic on the other, explored the influence that the language has on the development of logical and mathematical thinking. To quote: "The paucity of a language may result in ambiguities and confusion which must be resolved if it is to serve in modeling, problem solving, and logic. The richness of a language, on the other hand, can encourage associative thinking in that language, as well as the ability to make distinctions."

The second talk was a report of a detailed study of how (British) schoolchildren communicate in English about mathematics. The study examined pairs of lower secondary school age pupils describing geometrical patterns while sitting back to back. A number of interesting findings were discussed regarding the accuracy of reproducing the patterns, the way the various details were described and interpreted, the construction methods used, and the understandings and misunderstandings within the pairs.

2. Topic Group 11: The future of calculus

The only presentation in English was on calculus--past, present, and future by Paul Zorn. The rest were in Spanish, so, despite some degree of knowledge of that language and sincere efforts by the Chief Organizer Ricardo Cantoral to make the discussion multilingual, I could understand the talks only vaguely. It is my impression that the ideas on the teaching of calculus in various cultural "spheres of influence" differ so much that no agreement is possible.

III. What I Learned at ICME-8

As far as specific skills or methods of teaching or evaluation are concerned, I cannot say that I learned something completely new. In general, I believe that it would be difficult to objectively measure the benefits of attending a large international congress such as ICME-8.

On the other hand to participate in ICME-8, the first international congress of this kind I have attended, was a unique and unforgettable experience. I was enriched by being able to interact with mathematics educators from all around the world. I was stimulated by the several art exhibits which accompanied the congress and by various original materials such as videos, software, or even simple games, intended to popularize mathematics. I was fascinated by the diversity within the world of mathematics educators.

Just as an example, I greatly enjoyed the paintings of Rune Mields exhibited in Galeria Juana de Aizpuru in Seville. Each work was not only inspired by some mathematical idea but also contained a very clear mathematical message. In a way it existed at two levels: as an object of graphical art as well as an exposition or an illustration of a piece of mathematics. I was particularly struck by the three paintings based on the sequence of prime numbers. The global pattern of white squares in each painting was different, even though each time the same rule was used: a white square for a prime number, a black square for a non-prime number. The difference arose from the slightly different widths of the paintings--a fact of no importance for a person not interested in mathematics, but readily recognized by a mathematically inclined soul.

On the negative side, I returned from ICME-8 with a strong doubt as to whether the congress really united the mathematics educators from around the world. On many occasions it seemed to me that instead of a discussion, I witnessed several simultaneous but completely disconnected monologues. This was particularly evident in the work of Topic Group 11, where participants from various parts of the world spoke completely different languages, not only literally but also in the figurative sense. The problems they deal with in their everyday work are so different that there is no common ground for discussion.

To close, I feel that ICME-8 supplied me with a lot of material to think about. It will be a source of inspiration for years to come.

Lynnell S. Matthews

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I. Sessions Attended

Participating in ICME-8 gave me the opportunity to attend a variety of informative sessions. The opening plenary sessions on Whither mathematics education? and on the role of the mathematician in mathematics education provided me with an exhilarating conference inauguration. I participated in Working Group 16 on the role of technology in the mathematics classroom and Topic Group 4 on distance learning of mathematics. I attended the following regular lectures: Project work as a component of the mathematics curriculum; teaching math's anxiety--a circulus of aversion to mathematics with teachers and students; important cognitive changes in the learning of mathematics--a developmental perspective; new pedagogy and new content--the case of statistics; mathematics and common sense; and teach kids for their future, not our past. In addition, I was able to visit several poster presentations, the non-commercial and commercial exhibits and the sharing session for Two-Year and Technical Colleges.

II. Content of the Working Group and Topic Group Sessions

Working Group 16 on the role of technology in the mathematics classroom was organized by Marcello Borba (Brazil) and consisted of four productive sessions. The first session was a presentation by Rina Hershkowitz of the Weizmann Institute in Israel. Dr. Hershkowitz's main objective was to raise issues binding technological tools and the renegotiation of social/ sociomathematics norms in the math classroom. She discussed her involvement with the CompuMath project for middle school math. The project activities were characterized by technology-based investigation, student decision making, group or individual reporting of results, the teacher playing various roles and problem-situation oriented instruction.

The second and third sessions consisted of smaller subgroup discussions: elementary, high school and university. I attended the university level subgroup led by Jim Fey of the University of Maryland in the U.S. To begin we were asked to consider the types of effects technology has had on the mathematics classroom as they relate to: classroom tools, teacher roles, student roles and classroom tasks. Presentations from the USA and Columbia were made regarding research results from projects involving the use of technology in the classroom.

Mary Margaret Shoaf-Grubbs (USA), presented a paper on the role of technology in creating a positive learning experience in a first year college mathematics course for the under-prepared student at an all-women's liberal arts college. The paper reported the results of the use of a graphing calculator with a developmental math course at an all women's college. Dr. Shoaf-Grubbs emphasized that technology is an access tool to mathematics for all students. She concluded with a quote from Henry O. Pollack: "With technology: some math becomes important; some math becomes less important; some math becomes possible." Paola Valero (Columbia) presented a paper on teachers' beliefs and technology in the classroom. Two main ideas were discussed in the paper. First, a successful introduction of technology in class is the result of the application of the whole curricular change. To emphasize the need for a curricular change when incorporating technology into the classroom, she quoted James Kaput: "Technology without curriculum is not worth the silicon it is written on." (James Kaput, Annual Meeting of NCTM, 1994). Second, a teacher and his/her beliefs are relevant elements to be considered when trying to put into practice such a curriculum.

At the conclusion of these presentations, we subdivided into smaller groups: analysis/ calculus, statistics, modeling, linear algebra, geometry, teacher/student roles, software tools, new math goals and student/teacher interaction. Within these groups the goal was to formulate questions or concerns that characterized the current view of the role of technology in the classroom and its anticipated future effects on math education.

During the fourth session, the complete working group reassembled where a representative from each subgroup reported issues or concerns relating to the following topics: changes in student thinking and motivation; changes in mathematics and curriculum; changes in teachers; changes in pedagogy; changes in the educational system; changes in individual countries; and changes in assessment. In conclusion, two questions were posed to the working group members.

First, to the math education researchers: "Does technology truly enhance student learning? If so, can we acquire some evidence of this within the next four years?" Second, to the math practitioners: "Can we get an international agreement of topics that will be included or excluded because of technology?"

The topic group on distance learning of mathematics was organized by Haruo Marakami (Japan) and consisted of two days of short presentations on distance education. The presentations discussed several aspects of distance education ranging from delivering instruction via mail to satellite communications. There was a strong support of learning through distance education. Four themes characterized the distance learning of mathematics topic group:

1. A sharing and celebration of personal experience in distance teaching of mathematics.
2. A glimpse of the structure of current distance courses in mathematics.
3. A glimpse of the content of current distance courses in mathematics.
4. Some challenges to the education and philosophical assumptions that underlie themes 1, 2 and 3.

III. What I Learned at ICME-8

I was able to learn a vast range of things which will assist me in improving my classroom instruction. Attending enthusiastic regular lectures such as project work as a component of the mathematics curriculum by Paulo Abrantes (Portugal) enabled me to become aware of examples of project oriented models that have proven successful. Three examples of successful project oriented curriculum were presented: using math to make things happen—Halifax Primary School (England), calculus with applications—University of Campinas (Brazil), and the MATH 789 project (Portugal).

Teaching kids for their future, not our past was presented by Douglas Brumbaugh (USA) and provided several practical examples of using the graphing calculator in a high school level math course. Also discussed were the effects that the use of graphing calculators has had on course curriculum and student assessment exams.

The theme of new pedagogy and new content--the case of statistics presented by David Moore (USA) was technology, content and pedagogy in synergy. He pointed out that content and pedagogy should continue to drive instruction. Technology should serve the content and pedagogy. Also, technology can change the content and implementation of pedagogy in new ways. Thus, a synergy of technology, content, and pedagogy.

Teaching math's anxiety--a circulus of aversion to mathematics with teachers and students was presented by Christine Keitel (Germany). She discussed optimism and pessimism in math education as they related to math teachers and pupil's learning. Teachers' math anxiety was attributed to various reasons. Math anxiety of primary school teachers could be attributed to the teacher's lack of understanding, lack of ability, lack of meaning/sense, lack of relation/connection and/or lack of relating to persons/human beings regarding the subject. Math anxiety of secondary school teachers could be attributed to the dislike of abstract concepts which they perceived as uncertain, open or ambiguous. Desensitizing a teachers' math anxiety is important since it may be directly correlated to student-developed math anxieties.

Technology used in the mathematics classroom ranges from using hand held graphing calculators to multimedia delivered instruction. Issues regarding the use of technology range from access to implementation. Attending technology related sessions during ICME-8 enabled me to acquire an international perspective of the issues surrounding technology use in the mathematics classroom. The need to develop appropriate curriculum that technology can complement was a strong opinion. The need to train math teachers on how to incorporate various technologies in classroom instruction was also a prevalent concern. In summary, technological advances have begun to reshape the way we teach mathematics and will continue to affect mathematics education. As technological advances evolve then, so does mathematics education.

John A. Dossey

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Normal, Illinois

I. Sessions I Attended

I participated in ICME-8 in a number of roles. First, I represented the United States mathematics education community, as Chair of the U. S. National Commission on Mathematics Instruction of the National Research Council, at the General Assembly of the International Commission on Mathematics Instruction. I also participated as one of the organizers and speakers in Working Group 12 on curriculum changes in the primary school and as a participant in Topic Group 26 on international comparative investigations. My participation in the working group was predicated on my earlier participation in NAEP and TIMSS studies and the outcomes about the curriculum in grades K-4 and trends in both curriculum and teacher education related to those curricula from a mathematical content viewpoint. My participation in the topic group stemmed from my current membership on the Board of International Comparative Studies in Education (BICSE) and my membership on the Advisory Board for NSF/NCES for U. S. participation in TIMSS.

In addition to participating in the above sessions, I attended the opening day ceremonies and addresses and the regular lectures of Carolyn Kieran, Willibald Doerfler, Paul Cobb, and Peter Galbraith. In addition to these presentations, I attended the ICMI General Assembly, various project reports and project shows and browsed through the non-commercial and commercial exhibits of materials for mathematics education. Perhaps most of all, I enjoyed the breaks and intersession times to renew old acquaintances and meet new individuals interested in the same mathematics education topics as I am.

II. Content of Working Group and Topic Group Sessions

Working Group 12 on curriculum changes in the primary school began with a plenary address by Dr. Thomas Carpenter of the University of Wisconsin-Madison on planning primary curricula to build on children's informal mathematical thinking. Dr. Carpenter's remarks were based upon his research experience in working with children across his professional career, but most centrally on his recent experiences with the Cognitively Guided Instruction project (CGI) at the University of Wisconsin. He noted that there exists a substantial body of evidence about the mathematical knowledge that children bring with them to school. This body of knowledge is becoming sufficient for the construction and development of a curriculum for the primary grades, although work still needs to be done in some areas, such as probability and statistics.

The questions that the working group should consider deal with how should skilled teachers work to develop curricular materials appropriate for children in these grades; how can we formalize children's knowledge into a workable curriculum; and how do we adjust reflection and discussion to be child centered in such settings?

He then proposed three questions concerning notation for the participants to consider:

- What is the role of notation in primary mathematics and how should it be developed and linked to children's intuitions?
- How can notation be used to show children's thinking and used as a tool for recording problem solving on the part of children?
- How can children's own invented notation be utilized in the classroom and how can it be used to model the development of both operations and concepts? How should it be related to more traditional forms of notation for standard mathematical operations?

He then illustrated these questions with a variety of examples of children's work from the CGI project classrooms. These illustrations identified different student problem solving strategies and showed a variety of levels of depth in students' understanding of concepts central to anyone's definition of the primary grades' curriculum in mathematics. In particular, he noted that these original notations provide a basis for building on a student's constructions and discussion of alternative strategies by students. This was contrasted with the more conventional approach of just a way of "doing the problem." Considerable discussion was given to the allowance of students to utilize extended strings of "equality" like relationships, such as 50 + 40 –> 90 + 4 –> 94 + 8 –> 100 + 2 –> 102 in adding the numbers 54 + 48. Several felt that such notational conventions would allow students to adopt the incorrect notations associated with running equalities often seen in algebraic settings, strings which are not, in reality, real equality relationships.

Carpenter then discussed the findings of the CGI group in other areas, noting the work of Richard Lerher in geometry, with a question of finding all nets for a cube and then all nets for a tetrahedron. Here again he noted the role that notation plays in providing an object for reflection and a point for discussion. He noted that we need to consider:

- How curriculum can be designed to provide children with an opportunity to build on their informal thinking?
- How can/should notation be introduced to support children's inventions?
- What role should students invention of notation play in the school curriculum in primary mathematics?
- What should be the role of children's thinking in the formal development of the school mathematics curriculum?

Members of the working group then posed a number of questions of Dr. Carpenter. There was considerable interest in the ways in which CGI teachers have worked to bridge children from their invented notations to the more formal notations found in standard curricula. He noted that the CGI program has no specific recommendations on this at the present. He indicated that some teachers are more flexible in letting the invented notations run for longer periods of time than others. The central question was, he felt, not one of a specific time, but rather one of children having control over their own learning and confidence in their strategies to shift from their notation to that developed by others.

The next two days of the working group sessions were devoted to the presentation and discussion of papers contributed by group participants. In addition to the four questions proposed by Professor Carpenter in his plenary talk, working group leader Mary Lindquist asked that participants also consider the questions of:

- How do we approach administrators/politicians about research results concerning children's thinking and the role it should play in the primary grades?

- How can administrators better support teachers in their work to engender mathematical ways of thinking in primary aged children?
- How do we assist students who are slow in inventing their own notation and slow in joining into the investigation of mathematical situations?

The working group was split into three subgroups for the discussion of topics. Dr. John Dossey chaired the subgroup working with content issues for the primary grade curriculum, Dr. Douglas Grouws chaired the subgroup working with pedagogical issues, and Drs. Mary Lindquist and Carmen Burgues chaired the subgroup working on issues germane to the Spanish primary curriculum. Papers were presented in the content subgroup on the topics of changes in the number and operations curriculum in Australia by Dr. Joanne Mulligan of McQuarry University in Sydney, Australia; considerations for an alternative program for introducing rational numbers in Holland by Dr. Kees Buys of the SLO Project in the Netherlands; and algebra in the primary grades--bridging arithmetic to algebra by Dr. Jane Swafford of Illinois State University.

Dr. Mulligan reported on the changes in bringing their primary curriculum to a more relation focused subject in number, space, measurement, chance, and data. The role of links and reflection has come more to the front and focus on procedural work with algorithms more to the back. Instructional sequences have tended to move from prescriptive to reflectional in form with a heavier emphasis on building sophisticated strategies based on children's intuitions. Dr. Buys reported on the Dutch work to reshape the teaching of fractions in grades 4 to 6 of their primary program. In particular, they are rethinking the sequence to allow for the teaching of applications first, multiplication/division second, and addition/subtraction third. This sequence allows for a greater emphasis on student intuition and construction of meaning and strategies for dealing with rational number situations. He illustrated his work with student solutions to a problem involving the partitioning of 1 1/2 liters of lemonade among 4 glasses, each with a capacity of 1/3 liter. Students were supposed to tell how many glasses were filled and how much lemonade remained in the pitcher. Five different student solutions were presented and discussed relative to student understanding of the problem, student understanding of the underlying concepts, student understanding of notation and its use, and student ability to generalize and work with rational number concepts.

Dr. Swafford's talk dealt with a study carried out at the sixth-grade level with a colleague, Dr. Cindy Langrall. They focused on students' abilities to cognize three problem situations with algebraic overtones. They examined the students' abilities to recognize patterns, describe and explain the problem and its representation in tables and graphs. Finally, they examined students' abilities to generalize patterns, form equations, and solve the equations. Three problems were posed, one with refunds on soda cans, one that dealt with salary levels, and one that dealt with concert hall seating. The results showed that students at grade 6 level were able to create, recognize and represent the problems, even in symbolic form; to explore them through tables and graphical methods; to find solutions via these forms of representation; and to consider the use of variables as quantities that vary. However, they were unable to manipulate equations they had formed as a method of obtaining solutions.

The final session was devoted to two plenary talks, one on technology in the primary grades --a view to the future by Dr. Douglas Grouws of the University of Iowa and one on the implications of the TIMSS curriculum study for the primary curriculum by Dr. John Dossey of Illinois State University. Dr. Grouws noted the roles that technology can play in assisting students to represent, select modes for viewing mathematical situations, to examine patterns, to analyze data and patterns, and to develop justification for various generalizations. He considered the role of textbooks and how they might change as they might be used in combination with Web sites. Such use would have ramifications for teacher generation of activities, for greater roles for teachers in curricular decision making, and for funding patterns for classroom mathematics programs. He then turned to the topic of technology use. One use is for situations which cannot be learned without the aid of technology, or at least not learned as well. Such topics might be the consideration of the Powers of Ten video, the interactive Jasper series from Vanderbilt, and other data interactive settings drawing on the Internet. However, the use of technology to manipulate models of concrete objects on a video screen was questioned. He completed his presentation with a discussion of the implications of technology for situations involving equity; hand calculators have pointed the way in the development of questions related to the nature of student opportunities to learn. Technology can either promote it or stifle it.

Dr. Dossey presented a preview of the data from the TIMSS curricular study related to the curriculum contents of grade 4 mathematics at an international level. He discussed how countries might make use of this data in terms of comparing their curricula for the primary grades to that of their international peers. He stressed that the historical focus on achievement results from IEA studies might be inappropriate in terms of the wide variance in curricular contents, time of introduction, duration of focus, and levels of expectation associated with the topics during their study. He noted the relationships were not tied directly to geographical, economic, or political jurisdictions. The presentation provided a solid advance organizer for those interested in primary curricular questions, a source not previously available for those in primary mathematics education. The full study should be released in early fall 1996.

Topic Group 26 on international comparative investigations was devoted to a sequence of presentations on the first day and a panel discussion on the second. The first focused on an overview presentation by Gabriele Kaiser and then broke into smaller groups focusing on specific international comparative studies. I attended the one dealing with the TIMSS study. Papers were presented at this session by William Schmidt, Curtis McKnight, and Richard Wolfe. On the second day, there was a retrospect of the varied sessions from the first day and an overall consideration of the value of such studies by Geoffrey Howson, Christine Keitel, Jeremy Kilpatrick, Gilah Leder, Tom Romberg, Benny Nebres, and Richard Wolfe. Each of these presentations cautioned about generalizing too much from the achievement results and encouraged more targeted and confined analyses of the IEA data and smaller studies examining the mathematical nature of curriculum-teaching-achievement interactions in smaller venues.

III. What I Learned at ICME-8

The working and topic group sessions related heavily to my current involvement in the TIMSS study. The sessions reflected the wide international interest in this study and its potential for assisting in the framing and answering of a number of questions of great interest in mathematics education. The discussion in these sessions reflected a strong, international interest in developing curricula based on student construction of their knowledge. Several sessions dealt with the learning and teaching of algebra and the central role that algebra plays in the mathematics curriculum and in society in general. Student journals, communication, and inventions were central in the contributed posters and project areas, as were materials dealing with student competitions. Topics that are of interest in stateside meetings of teachers at state, regional, and national levels are also of major interest in international settings. Technology continues to be a major source of interest, but financial considerations make the worldwide use of technology less practical and implementable at present. Throughout the meeting, the focus on student learning and quality teaching/curricular materials was immediate.

Sadie C. Bragg

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Introduction

As a member of the arrangements committee, it was an honor to represent MSEB in selecting the United States awardees to attend ICME-8 in Seville, Spain during July 14-21, 1996. Of equal honor, I too received a travel grant. This was my first time attending an ICME congress; the experience was interesting and professionally rewarding. I look forward to attending ICME-9 in Japan.

I. Sessions I Attended

Due to prior professional commitments, I did not arrive in Spain in time to attend the opening session on Sunday, July 14, 1996. My congress experience began on Monday with the international round table discussion. On Tuesday I attended Working Group 14 sessions and regular lectures on mathematics education--an Oriental point of view, highlights and shadows of recent Japanese curriculum for secondary schools, and upliftment initiatives in South Africa--an INSET project. On Wednesday I attended Working Group 14 sessions and lectures on mathematics competitions in China--success and deficiency, and social constructivism as a philosophy of mathematics. I began Friday with Working Group 14 sessions followed by a lecture on issues in assessment--a never ending story and Topic Group 13. On Saturday I concluded my work in Working Group 14 and Topic Group 13 and attended the sessions on Russian standards--concept and decisions, sharing session for Two-year Colleges and Technical Colleges, and the ICMI Study--what is research in mathematics education and what are its results?

II. Content of the Working Group and Topic Group Sessions

Working Group 14—Linking mathematics with other school subjects.

Working Group 14 was divided into four areas—statistics, society and environment, modeling, and secondary education. After listening to each of the presentations on the four areas, I decided to participate in the session on secondary education led by sub-organizer John Gillespie. I chose this area because it appeared to be more inclusive than the other three areas. In fact, the secondary education area included modeling, society and environment.

Working Group 14 was presented over a four day period, Tuesday through Saturday. Tuesday was devoted to organizing the sub-groups into the four areas mentioned above. On Wednesday presentations were made on making sense of mathematics in the newspaper by Ronald Keijzer en Kees Buijs; mathematics and geography by Alicia Villar; and what mathematics can be found in pre-vocational subjects by Pieter van der Zwaart. The Friday session included the following presentations: conceptualizing the use of art for the teaching of mathematics by Anna Chronake; the application of math in the art and design class by John Gillespie; and modeling fitness--linking mathematics and health education by Sonia Jones and Howard Tanner. The group received handouts on each of the presentations. On Saturday the entire group had an opportunity to make comments and to present 2-3 minute presentations on issues related to the theme of the working group.

The emphasis in each of the presentations was on students' attitudes about mathematics, ethnomathematics, critical thinking in mathematics, visual learning, contextual learning, modeling, the use of real-life situations, and technical mathematics for non-college bound students. There was much discussion on integrating mathematics and other school subjects and how to strike a balance between mathematics learning in contexts and mathematics learning in isolation.

In the general session, I shared with the group some of NCTM's and AMATYC's viewpoints on the issues discussed in Working Group 14 as they relate to the Standards and Crossroads documents, respectively.

Topic Group 13—The future of algebra and arithmetic.

This group focused on number sense, mathematics--algebra research and teachings, and epistemological reflections. We pondered the following questions: Which developments in research will be important in algebra and in arithmetic? Does algebra really exist outside school? What could be the sense of learning arithmetic and algebra? How do we get students to be algebra thinkers? There were two presentations made in the Topic Group 13, one by Alan Bell of the United Kingdom and the other by Bill Atweh of Australia. Both of their studies focused on innovative aspects, projects and proposals for the new ways of treating algebra and arithmetic throughout the curriculum. After much discussion, the group did not reach a consensus on the future of algebra and arithmetic. But it was felt by some that algebra is still the filter for mathematics for high school students.

III. What I Learned at ICME-8

As mentioned earlier, ICME-8 was my first international congress. In general, I found the congress to be more rewarding in small group discussion with colleagues from America and other countries, outside the regular scheduled sessions. One of the things I learned is that there are similar problems in mathematics education throughout the world. The biggest problem being how do we as mathematics educators get "all" students to learn mathematics. I distinctly got the feeling in both my working group and topic group, as well as in our discussions, that we have much work to do to make mathematics more meaningful to our students. I clearly recognize from these discussions that this is not just an American problem.

I specifically chose to attend sessions that focused on secondary education in other countries such as South Africa, China, Japan and Russia. In light of the upcoming TIMSS Report, I wanted to have a better understanding of some of the problems as well as the successes in mathematics education in these countries. It was confirmed in these sessions that these countries have just begun to struggle with education of the "masses," that is, all students. I learned that countries such as England and Spain have similar problems in mathematics at the secondary level as we do in America.

In the session on the ICMI Study, I found out that mathematics educators internationally still have a great deal of work to do to reach consensus about what is research in mathematics education. This session was very well attended and quite provocative from what to include in the report to who should publish it.

In the sharing session on Two-Year and Technical Colleges, I learned that there is a great need to have more opportunities for faculty who fall in this area to be representated at the ICME congresses. At this session, it was expressed by all of the attendees that as our countries address issues of educating "all" students, there is a need to include two-year and technical colleges in these international discussions on mathematical education.

I enjoyed attending ICME-8, the hospitality of our Spanish hosts, the dialogue with my colleagues from America, the exchange with my international colleagues, the dynamics of the working group and the topic group, and the vast range of session topics.

I plan to share my experiences at ICME-8 with my colleagues at MSEB, AMATYC, NYSMATYC, and with the City University of New York Mathematics Discussion Group. I will be presenting on ICME-8 in a session at the annual AMATYC Conference in Long Beach, California.

I am grateful to MSEB, NSF, and NCTM's arrangements committee for giving me the opportunity to have this experience and to have my interest stimulated for ICME-9 in Japan.

Sunday A. Ajose

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I. Sessions Attended

I attended all the sessions of Working Group 21 and Topic Group 21. Working Group 21 focused on the teaching of mathematics in different cultures while Topic Group 21 addressed issues related to mathematics instruction based on manipulative materials. I also attended four regular lectures and participated in a research session organized by the International Group for the Psychology of Mathematics Education (PME). I convened the meeting of the International Study Group on Ethnomathematics (ISGEm), and over a two-day period, visited every poster display at the congress.

II. Content of Working Group and Topic Group Sessions

Working Group 21 explored four aspects of mathematics education in multicultural settings. These are:

1. The influences of culture on teaching and the curriculum;
2. Preparing teachers to teach to diversity;
3. Cross-cultural research; and
4. Mathematics learned outside school.

The first of the four 90-minute sessions allotted to this working group was devoted to two memorable, thought-provoking plenary lectures. The first speaker expounded on her thesis that mathematics is cultural practice and that to learn mathematics is to become socialized into its special ways of knowing. The second speaker used the spider web as a metaphor for an individual's knowledge schema. The process of mathematical learning for each child is, therefore, like building a mathematical web. Teaching, the speaker suggested, should empower children to improve and extend their webs rather than destroying those webs and having them rebuilt like the teacher's own.

During the second and third sessions, the participants met in four smaller groups, each of which discussed one of the four topic areas listed above. Many papers were presented in these groups by scholars from several countries before a combined audience of more than a hundred each day! Presentations were followed by questions and reactions from the audience. The large number of presenters and the need to translate the lectures into Spanish left little time, unfortunately, for critical discussion at some of the sessions. However, the presentations and ensuing scholarly exchanges reflected both depth and breadth of thought about the subject of the working group. The group concluded its work with a third outstanding plenary speech by a Canadian researcher who spoke about the learning of geometry by the Inuit minority group in his country.

Members of Topic Group 21 were brought together by a shared interest in the use of manipulative materials in mathematics instruction. After a brief welcome by its chief organizer, the group divided into three subgroups according to levels of mathematics instruction. I joined about a dozen other mathematics educators with interest in mathematics instruction at the elementary level. The two other subgroups focused on the role of manipulative materials in mathematics instruction at the secondary and tertiary levels.

In the elementary mathematics education subgroup, members posed specific questions about manipulatives that they would like to investigate. We tried to develop a framework for classifying manipulative materials. The two leaders of this subgroup urged all in attendance to research some of the issues raised and attempt to publish the results.

III. What I Learned at ICME-8

I went to ICME-8 with high expectations and I was not disappointed, especially by Working Group 21. There seems to be a global realization that:

1. Culture influences all aspects of mathematics,
2. To base school policy and practice on the assumption that mathematics is culture free is to put certain groups of students at a disadvantage—"at risk"; and

3. Low-status minorities in different countries face some remarkably similar problems with respect to their school experiences and learning of mathematics.

Moreover, I learned that while we seem to be ahead of other countries in the use of technology in math instruction, our elementary mathematics curriculum is weak. We expect far less of our K-8 students than other countries do. Even the recommendations in the NCTM Standards for this level are not strong enough.

Like the United States, many other countries are struggling to meet the challenge of diversity in the classroom. It is generally agreed that teacher education is crucial in the efforts to meet this challenge. Conference attendees from the United States who presented papers in Working Group 21 were among those who made significant contributions to the deliberations on how to educate mathematics teachers for diversity. Suggested measures to take include:

1. Making instructional use of students out-of-school mathematical experiences, their ethnomathematics;
2. Providing culturally relevant field experiences for prospective teachers; and
3. Modeling appropriate teaching strategies in courses for preservice teachers.

One of the principal benefits of ICME-8 was the opportunity it provided scholars from countries around the world to interact, learn from each other, and collaborate on research projects. Both the Working and Topic Groups enabled me to form partnerships to continue to research issues on the use of manipulatives and the cultural aspects of mathematics education.

Lillie R. Albert

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Sessions I Attended

The sessions I attended at ICME-8 included: an international roundtable discussion moderated by Alan Bishop on mathematics teachers as decision makers--changes and challenges; a plenary lecture on the role of mathematicians in mathematics education by Miguel De Guzman; several regular sessions on the professional development of teachers in various countries (e.g., USA, Austria and Mozambique); the working groups on communication in the mathematics classroom and on gender and mathematics; and the topic group on problem solving throughout the curriculum.

Content of the Working Group and Topic Group Sessions

Working Group 1 on communication in the mathematics classroom focused on quantitative and qualitative empirical research ideas, results, and problems about classroom communication. There were three major areas of emphasis. These consisted of the following: examination of theoretical approaches about student-teacher interactions; research engaged in descriptive analysis (e.g., intervention studies); and studies that focused on individual and small group conversations.

The gender and mathematics working group discussions focused on issues and research about past and current developments from national as well as international perspectives. Some of the major topics were about social and cultural influences on gender-differentiated attitude towards mathematics, policies concerning curriculum and assessment, and reflections on research methodology and theoretical paradigms.

Topic Group 10 on problem solving throughout the curriculum was centered around theories and practices that encourage students to use mathematics in classroom and real-world settings. Discussions and papers included information about teacher education and empirical and philosophical research studies about children's metacognitive thought processes.

What I Learned at ICME-8: An Informal Conversation

The common theme that spread across many of the general sessions and working group discussions provided an international perspective about the issues and concerns of teaching and learning of mathematics. There was a great deal of discussion, especially among researchers, about the impact of empirical and theoretical research on student learning and the professional development of teachers. Several contributors suggested that it is the inherent responsibility of researchers to ensure that research implications address key elements in teacher education (e.g., cultural realities, gender differences, and equity).

The following example might make these ideas clearer. For instance, considering the work in the area of gender and mathematics over the last twenty years, international scholars suggest that there is still much to be done in the areas of equity and social justice. The focus on gender within the debate that continues to accept the idea that school mathematics is used more than any other school subject in society implies that constructive reevaluation of how to improve mathematical learning for women must continue. Educators in the United States are also facing many of the same issues; therefore the discussions about how to promote social justice in mathematics education interested me the most. Because my interest expands beyond issues of gender, it is clear to me that these discussions must not ignore the challenges faced by other marginalized students in mathematics classrooms. The idea is to provide equal access to the mathematics curriculum for all students. As an educator, I am concerned with how we educate teachers to provide meaningful learning experiences and activities for all students; also as a researcher, I am equally concerned with how to document "this idea" of equal access.

The themes of "equity and social justice" and "teacher professional development" in the areas of pedagogical practices were addressed in a paper presented by Atweh, Bleicher and Cooper (1996) of Queensland University of Technology. Contradictions and conflicts teachers face in their classroom practices are not caused by lack of knowledge or skills or from inconsistencies in beliefs and values but arise because the awareness of the context of teaching is inherent in the value systems of schools and society that define teachers' work. For example, teachers, to a certain degree, are aware of how they relate to the gender and backgrounds of students they teach, yet they continue to teach in ways that marginalize these students.

> [T]eachers are aware that the content of many school mathematics programs is selective and values the mathematics that is thought to be formal and abstract. Teachers face a dilemma of either teaching this valued mathematics to all students, irrespective of their ability, interests or mode of thinking, and hence doom some to failure, or modify the mathematics to suit the needs and abilities of the students, and hence, limit the access of these students to higher studies (p. 15).

It was proposed that educators need to reconceptualize and reconstruct professional development activities. Activities and experiences should not be limited to knowledge and skills but should be linked to beliefs, values, and attitudes. Placing more emphasis on helping teachers critically examine their beliefs, values, and attitudes is a good starting point for taking into account alternative ways of teaching in diverse classroom environments.

There were several discussions about problem solving and classroom communication. From my perspective, there was not a dominant response to what is problem solving, how to teach it to students, and how to examine constructively the role of collaborative conversations within the context of subject matter learning. Several studies presented implied that when students are challenged to solve complex problems through collaborative discussions they drew on their shared knowledge. In other words, the shared conversational reasoning supported students' search for meaning and led them to new mathematical thinking.

In conclusion, one of the foremost points stressed by many participants is that studying and addressing the dynamics of classroom communication and other ideas in mathematics education is very complex. Nevertheless, we must continue to study these areas and find ways to alert educators to acknowledge and value students' mathematical experiences inside and outside the classroom. It is important that teachers provide classroom experiences that are relevant to students' experiences and ideas. Equally important is for researchers to link their findings and implications to practical applications that transform classroom practices. We need to consider how quality mathematics education can be provided for all children.

Attending an international meeting on mathematics education provided opportunities for me to extend my own mathematical perspectives about current research problems, ideas, and concerns in regard to teaching and learning. The organization of the conference sessions allowed me to be an active participant in the discussion process. This made the presentations rich and meaningful to me.

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John W. Alexander, Jr. (Jack)

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I. Sessions I Attended

The first "session" that I attended was the U.S. National Commission on Mathematics Instruction (USNCMI) meeting, which met on Sunday July 14, 1996 at 8:30 pm. This was the second meeting for the commission in 1996. The first meeting was held in January during the joint mathematics meetings in Orlando, Florida. I attended both meetings in my capacity as NRC program officer responsible for USNCMI operations.

My second session attended, which was held at 8:00 am on Monday the 15th, was an information and orientation meeting of travel grant awardees for ICME-8. This useful gathering provided logistics assistance and gave awardees some focus as well as an idea of what to expect. In retrospect, this meeting did, in fact, help me to get the most possible from the congress.

The rest of Monday was consumed with the official opening ceremony, two plenary lectures, an international panel (mathematics teachers as decision makers), a welcome cocktail hour, and an evening performance.

On Tuesday, Wednesday, Friday and Saturday, from 8:30 to 10:00 am, I attended Working Group 15 on the impact of technology on the mathematics curriculum. Thursday the 18th was a free day. The chief organizer for Working Group 15 was Michal Yershalmy from Israel. The table below gives the day, time, and title of the other sessions that I attended on Tuesday, Wednesday and Friday.

DAY	TIME	TITLE	PRESENTER
Tuesday	10:30-11:30	Teaching and learning in elementary analysis	Michele Artique
	12:00-13:00	Applications reform--a brief history in time	Sol Garfunkel
Wednesday	10:30-11:30	Mathematics education and gender issues	Gilah Leder
	12:00-13:00	New pedagogy and new content in statistics	David S. Moore
Friday	10:30-11:30	Issues in assessment--	Peter Galbraith

a never ending story

On Friday and Saturday, from 12:00 to 13:30, I attended Topic Group 15 on art and mathematics. The chief organizer for Topic Group 15 was Dietmar Guderian from Germany.

IIa. Content of Working Group

While the speakers that gave presentations for Working Group 15 were quite interesting, there was, in my view, far too little time allocated for discussion and interaction.

The most valuable and useful information, I am proud to say, came from my former protégé Professor Pat Thompson. Pat was my assistant in a West African mathematics education program back in the early 70's. Pat demonstrated, with excellent and humorous overheads, some of the possible pitfalls of incorporating too much technology too soon. He made the point that whatever technology we promote will be filtered by the teacher. He cautioned that giving students powerful computer and calculator tools does not necessarily clarify conceptual understanding.

One of the other speakers (Collette Laborde, France) made the excellent point that technology should be integrated into the fabric of mathematics courses. Artificially tacking on calculator or computer sessions that do not work in concert with the material being presented in the body of the courses has the potential to create confusion. She also made the point that new questions and different expectations must be considered when designing technology-based courses and software.

Kathleen Heid also talked about the importance of matching software with the course goals in a mathematics course. She made the point that it is important that teachers try to learn how to develop some of their own software. This ability gives the instructor more flexibility in designing technology-based curriculum materials.

All speakers emphasized the need for teacher retraining and/or reorientation. The consensus was that the desired classroom of the future would give students far more independence. There would be more opportunity for discussion and interaction in a climate where students could learn from each other, from the technology and from the teacher. In this setting both the teacher and the students will be in a constant learning mode.

IIb. Content of Topic Group

These sessions were, by far, the most enjoyable to me. The chief organizer, Djetmar Guderian, did an excellent job in his own presentation, which set the stage for the others that followed. His historical overview illustrated that all cultures, from antiquity to the present, have employed mathematics as a foundation for architectural and artistic design. He gave graphic illustration of this when used in basic building construction and ornamentation.

While all of the presenters displayed fascinating slides and overheads, the two most memorable were the speakers from Argentina and Japan. Alicia Sara Villar from Argentina shared with us a wealth of art work from the ancient civilizations of South America. The presentation included many intricate designs which presumably provided stimulation for more contemporary tessellation expressions like those of Escher and others. Kiyoshi Yokochi from Japan gave an in-depth presentation on projective geometry through the vehicle of ancient and modern Japanese paintings of houses, buildings and temples.

III. What I Learned at ICME-8

Before going to ICME-8, it was clear to me that there is a significant amount of controversy surrounding the use of technology in connection with mathematics education. To get some further insight into the pros and cons, I signed up for the Working Group 15 on the impact of technology on the mathematics curriculum.

From attending these sessions, the prevailing wisdom was that an effective curriculum that makes significant use of technology is most likely to develop only with a well conceived systemic approach. This implies that the entire school, college or university has to be involved.

The administration must be flexible—allowing for innovative scheduling for faculty and students as well as physical restructuring of classroom spaces. They must also provide resources for computer and calculator equipment, funds for teacher training, and release time for faculty to develop technology-based classroom materials.

The faculty must be willing to participate and deal with the learning curves that are typically associated with new technology systems. In some situations, outside consultants might be necessary, not so much to teach faculty how to use the technology, but to sensitize them to the importance of relinquishing the central role of the teacher in a classroom setting.

Sensitivity work must also be done with students. Working in a group setting or responding to a computer workstation may be foreign to many students. Students oriented to a lecture format may feel that the teacher is not "teaching" them if the teacher takes on the role of a learning facilitator as opposed to the sole provider of knowledge.

As I stated above, I really enjoyed the art and mathematics topic group. These sessions gave me numerous ideas for how to motivate discussion and mathematical activities using artistic patterns, perspective drawings, and architecture. At least three of the presenters commented that a closer cooperation between artists and mathematicians would be beneficial to both disciplines. This concept would provide a perfect vehicle for team teaching and a wonderful enhanced experience for students.

I had a suspicion that there was a great deal of difference in how people address the problems of imparting mathematical knowledge around the world. I must say, that what was surprising was the magnitude of the diversity. Probably the most important thing that I learned is that congresses like these are absolutely critical if we are ever to come close to bridging the gaps. These ICMEs are, in my view, a powerful vehicle for not only improving mathematics education, but are also invaluable in promoting intercultural understanding. I was very happy to be a part of this experience, and learned a great deal about mathematics education from the people that I met.

Joanne R. Becker

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I. Sessions I Attended

At the congress I participated in Working Group 6 on gender and mathematics and Topic Group 2 on secondary school mathematics. In addition to the plenary lectures, I attended lectures by Kath Hart, Ubiratan D'Ambrosio, Tom Cooney, Gilah Leder, Alba González Thompson, and Paul Ernest. I participated in the meetings of the International Organization of Women and Mathematics Education (IOWME), an ICMI affiliate, speaking on the plenary panel at the first meeting of the group about the current status of research on gender and mathematics in the U.S. I also perused a number of posters.

II. Content of the Working Group and Topic Group Sessions

The working group on gender and mathematics started with a plenary session in which a panel of participants discussed findings from the ICMI study on gender and mathematics and reviewed the status of women in mathematics in their individual countries. For the next two sessions, the working group broke up into smaller subgroups to focus on: different research perspectives; manifestations of gender inequities; ethnic, cultural and social conditions associated with equity issues; international, regional and local cooperation in research; and focus on directions for change in educational contexts. I participated in subgroup 1 on different research perspectives. In this subgroup we had a variety of presentations and extensive discussion, including an overview of the historical development of explanations for gender differences in mathematics by Fidela Velázquez and a philosophical discussion of how views of mathematics affect one's learning of the subject by Paul Ernest. Finally, this working group reconvened into one large group for the last session, and each subgroup reported the key ideas discussed. These reports provided an overview of the participation and achievement of women in mathematics in various countries. The division into subgroups provided an opportunity for many more people to contribute to the work of the group. The results from the subgroup reports were summarized very nicely by Gilah Leder, who identified three common themes from the five subgroups' work. These are:

- Mathematics is culturally situated and not value-free.
- We can learn from each other's experiences, but if mathematics is culturally situated, how do we transfer our knowledge?
- Participation and performance data need to be interpreted cautiously.

Leder also identified a number of challenges for future work. Although we have identified some interesting between-country differences, we haven't explained them. Much of the work reported focused on performance and participation; more research needs to be done on the reasons behind gender differences. Our work has focused exclusively on schools and what happens within schools; the influence of parents and society at large needs attention. What is the impact of new technology on girls and women? We must move away from a deficit model for investigating gender differences and allow new models, such as a social justice model or women's ways of learning, to inform our work.

This working group and IOWME jointly had a very nice booklet published by our Spanish colleagues, including the abstracts of all the presentations and the addresses of presenters. Hopefully this booklet, 20 Years of Cooperative Research on Gender and Mathematics: Where We Are, Where We Go, (Keitel & Luelmo) can be more widely distributed. It may be ordered from:

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I do not know the cost as the book was given to whomever attended IOWME or working group sessions. It might be best to inquire as to cost.

The topic group on secondary school mathematics held two sessions, both of which included extensive presentations. The first session included presentations by Jan de Lange and Zalman Usiskin, focusing on the big ideas in mathematics and how these should impact the curriculum at the secondary school level. Jan de Lange listed the big ideas to be problem solving, technology, reasoning, visualization, and integration of mathematics with other subjects. He stated that artificial integration is unmotivating and leads students to think of mathematics as useless in the real world. Curriculum must include real integration and uses of mathematics which interest students while at the same time engaging their imaginations. Usiskin listed four big ideas: math is useful; mathematical truth is established by deduction; algorithms are powerful procedures that allow whole classes of problems to be solved; and representations and morphisms are powerful mechanisms for understanding and doing mathematics. His conclusion from these big ideas is that the curriculum should include much more statistics and discrete mathematics, while not neglecting deductive development and algorithmic procedures, perhaps considered more "traditional."

In the second session of this topic group, several presentations illustrated curriculum materials which formed the core of discussion about the common directions of reform in mathematics at the secondary school level around the world.

III. What I Learned at ICME-8

There are a number of items I would like to highlight that I gleaned from attendance at ICME-8. First, Kath Hart's presentation on the responsibilities of researchers to teachers and children included her definition of research (borrowed I think from a PME statement of a number of years ago). Hart said research needed to included five aspects:

- There is a problem;
- There is evidence or data;
- It can be replicated;
- It is reported; and
- There is a theory.

This characterization of research stimulated me to think about the type of qualitative research in which I engage. In this type of research, one frequently is discovering grounded theory rather than testing existing theory. Thus, in some sense there may not be a theory as the research is undertaken. Second, in staff development with secondary school mathematics teachers, I have tried to engage them in action research. This may not always be "reported," unless reporting includes informal sharing with a network of other teachers. Unfortunately, because of time constraints, I did not have time to discuss these issues with Kath Hart.

Paul Ernest's erudite lecture on social constructivism as a philosophy of mathematics provided a provocative critique of absolutism in philosophy of mathematics and gave me a number of new ways of thinking about mathematical knowledge, such as fallibilism. Such philosophical considerations are important to me as a teacher educator as I work with new teachers who are reflecting on their views of mathematics and how they affect their teaching of mathematics. The connection Ernest made in the Working Group on gender and mathematics between philosophical views of mathematics and Carol Gilligan's and Belenky's, et al. feminist research into women's development was also of great interest to me in my research on gender and mathematics.

Tom Cooney's lecture on conceptualizing the professional development of teachers was of special interest to me because a great deal of my work entails inservice education with teachers K-12 as the project director of a National Science Foundation teacher enhancement project, an Eisenhower project, and a state-funded California mathematics project. One of the most interesting aspects of Cooney's talk involved the theoretical models he uses to inform his work, including Perry and Women's Ways of Knowing (Belenky, Goldberger, Clinchy & Tarule, 1986). Because I have done some work with Women's Ways of Knowing in my research on gender differences, it was intriguing to hear this model being applied to preservice teachers to analyze their perspective on mathematics as a science and on its fallible nature. This stimulated me to consider applying these theoretical models in my research with inservice teachers.

One thing that disappointed me, however, is that this session had no discussion of development of teachers' beliefs relative to equity issues. This reinforces for me the fact that issues of equity are not fully salient in every discussion of teacher development, as I think they should be.

Leder's lectureon mathematics education and gender issues provided an excellent historical overview of work on gender and mathematics, included a comprehensive outline of the myriad explanations for gender differences in participation and performance in mathematics that have been studied since the 1970s. Peggy McIntosh's model of transformation of curriculum, adapted by Kaiser and Rogers (1995) to mathematics, is a provocative one for us to consider in designing culturally relevant curriculum. This model progresses through five phases:

- Phase I: Womanless mathematics (mathematics as a male domain);
- Phase II: Women in mathematics (some historical figures studied);
- Phase III: Women as a problem in mathematics (deficit model);
- Phase IV: Women as central to mathematics; and
- Phase V: Mathematics reconstructed.

These phases are useful to me as reminders in my own research on gender.

Perhaps the most useful aspect of participation in the congress, as usual, is the interaction with so many colleagues in mathematics education from around the world. Such interaction serves to break us out of the ethnocentrism from which we in the U.S. suffer. There are many important and even better ideas being generated in other countries which should inform our work to help us improve mathematics education for all of our students.

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Thomas J. Cooney

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Sessions Attended

I participated in Working Group 2 on forms of mathematical knowledge, organized and chaired by Dina Tirosh (Israel). In this working group, I gave a short lecture on conceptualizing teachers' forms of knowledge. I also attended Topic Group 2 on secondary school mathematics, organized and chaired by Glenda Lappan (U.S.). I attended the plenary addresses by Anna Sierpinska (Canada) and Miguel De Guzman (Spain) and regular lectures by Anna Sfard (Israel), Gilah Leder (Australia), Konrad Krainer (Austria), Alba Thompson (U.S.) and a session on gender and mathematics education. In addition, I presented a regular lecture on conceptualizing the professional development of teachers. I also spent a considerable amount of time with various leaders in mathematics education, discussing issues of relevance to them in their countries. In many ways, this was the most valuable part of the ICME experience.

Working Group 2: Forms of mathematical knowledge

Working Group 2 was organized around presentations by Tommy Dreyfus (Israel), John Mason (England), Paul Ernest (England), David Tall (England), Anna Graeber (U.S.A) and myself. Dreyfus addressed the question, "What constitutes a mathematical explanation?" He noted that over time this question has taken on many facets including proofs by computers, probabilistics proofs, and experimental proofs. He also addressed the question, "What kinds of mathematical arguments make sense to teachers and students at various levels?" which is related to the question, "Who decides what arguments are acceptable and what criteria are used?"

Mason identified different kinds of knowing including the traditional categories of knowing why, knowing how, and knowing that. He focused on the importance of "knowing to" as reflected, for example, in Polya's heuristics for solving problems. Knowing to, according to Mason, exists "in the moment" and is context dependent. Mason emphasized the importance of making explicit various kinds of knowing to so that an individual can develop a recognition as to when a procedure should be "activated" to solve a problem. Another element of knowing to is the confidence one develops when using mathematics. Confidence is needed to expand, to explain, and to act in situations not previously encountered.

Ernest emphasized the importance of recognizing the fallibility of mathematics and the implications of that fallibility for both the teaching and learning of mathematics. This perspective leads to the notion, according to Ernest, that mathematical knowledge is tacit situated, that is, what we know is largely situated in a social context, leading to the notion of "situated cognition." This is consistent with the constructivist epistemology that holds that knowledge is constructed by the individual and is dependent on the contexts in which the individual finds himself/herself.

Tall (and colleagues) presented a theory that considers the growth of mathematical knowledge from child to mathematician and the divergence in success between those who succeed in mathematics and those who fail. A key element of the theory is the notion of proceptual thinking. Proceptual thinking is a flexible type of thinking in which the individual can perform mathematical processes but thinks conceptually while doing so. Procedural thinking, on the other hand, focuses only on the doing of mathematics rather than on the flexible kind of thinking associated with proceptual thinking. In elementary mathematics, less successful students tend to remain longer in the figural and procedural aspects of mathematical learning than their successful counterparts. They fail to develop flexibility in their mathematical thinking. At advanced levels, less successful students focus on figural and proceptual images without realizing the generative power of mathematics couched in a structural system.

Graeber raised the question of what big ideas teachers should have about forms of students' knowing. She pointed to the importance of teachers understanding different ways of knowing and that students having one form of knowing do not necessarily have access to other forms of knowing. Intuitive knowledge is both an asset and a liability in that it provides insights into mathematics but may inhibit acquiring a more generative view of mathematics. A critical question for teacher education is how we can help teachers develop an understanding of and appreciation for the different forms of knowledge as they develop and exist in the classroom.

These presentations fit well with my own presentation on forms of teachers' knowledge. It was quite interesting to me that the other presenters made frequent reference to the question, "What kind of knowledge do teachers need to promote reform in mathematics education?"

Topic Group 2: Secondary school curriculum

There were two main "tension points" that arose in the topic group presentations and discussions. First, there was the tension between mathematics as a structure and a subject worthy of study in its own right and mathematics as a tool for investigating real-world phenomena. This tension became apparent in the problems the speakers emphasized for secondary school students. I thought it significant that the view was expressed that the pendulum has swung too far toward mathematics as a tool for solving application-oriented problems as advocated in the NCTM Standards.

The second tension point centered on the issue of assessment for learning secondary school mathematics. The current emphasis on using alternative assessment is fraught with issues of subjectivity in grading and the difficulty teachers have in creating and using open-ended items. On the other hand, if one supports an expanded view of mathematics, then assessment practices must match this expanded view.

What I Learned at ICME-8: The increasing complexity of mathematics education

This was the sixth ICME I have attended, my first being ICME-3 in Germany (1976). I am continually impressed with the sophistication of questions being asked and the emerging appreciation for the complexity of the issues in question. Too, it is interesting that teaching and teacher education are much more at the center of the discussion than I recall from the earlier ICME's--especially those of the late 1970s or early 1980s. Previously, the problems seemed to be subservient to mathematical considerations. Today, mathematics education is seen as a product of both psychological and sociological phenomena involving mathematics but not limited to mathematics.

There are two emphases that I believe differentiate ICMEs 7 (Quebec) and 8 (Seville) from ICMEs 3 (1976) and 4 (1980). The first has to do with the epistemological orientation toward mathematics that suggests it is a humanistic endeavor. The notion of constructivism, currently the dominant epistemology in the U.S.A, holds this tenet as primary. The Europeans are less likely to embrace explicitly constructivism as an epistemology albeit they tend to embrace mathematics as a human endeavor. A second emphasis that I see emerging in the ICMEs is the emphasis given to teaching and teacher education. Howson, in his Quebec ICME address, put the teacher as the focal point for reform in mathematics education. At the Seville ICME there was considerable attention given to the professional development of the teacher. Presentations by Ernest (England), Graeber (U.S.A), and Mason (England) raised the question of what type of knowledge teachers need to have in order to teach mathematics from a relativistic perspective. It seems that, as a profession, we have come to finally appreciate that unless teachers possess the kinds of insights and knowledge that enable them to deliver a broader based curriculum, reform will be limited to the rhetoric rather than the practice of reform.

I found the regular lectures to be quite interesting. Sfard (Israel) made the point that powerful theories are those that involve a multitude of compatible perspectives. She distinguished acquisition metaphors which tend to be more static from participation metaphors which tend to focus on the process of acquiring or creating knowledge. Participation metaphors are more consistent with the constructivist notion that mathematics is a human endeavor. Thompson (U.S.A) identified three types of curricula: the calculational curriculum, the curriculum of processes, and the conceptual curriculum. The calculational curriculum focuses primarily on the acquisition of techniques and procedures. The curriculum of processes includes an emphasis on analyzing, generalizing, and solving non-routine problems. The conceptual curriculum consists of ideas, concepts, and relationships. Thompson's observations led her to conclude that there is an overemphasis on the calculational curriculum to the exclusion of other mathematical outcomes. This, again, points to the need for upgrading the training of teachers, first to allow them to understand the difference among these three types of curricula, and secondly, to develop the means by which they can teach these different curricula in a reasonable way.

Krainer's lecture on inservice education emphasized the complexity of problems teachers encounter. His notion of a teacher's "critical friend" is quite important. His technique of having a teacher present a classroom problem followed by other teachers asking factual questions of the teacher before any suggested solutions are offered is the essence of a good inservice program. It provides a context of cooperation and respect for the contexts in which teachers find themselves. It communicates the importance of listening to teachers and of recognizing the complexities in which teachers find themselves. In his lecture, Krainer raised two questions. The first was whether we expect too much of teachers given the lack of support they often face and the demands placed on them to continually innovate in some way using, for example, problem solving or technology. On the other hand, Krainer asks the question if we expect too little of teachers in that teacher education programs often fail to honor the insights teachers possess in dealing with complex situations. Too often, argues Krainer, teacher education programs fail to listen to what teachers have to say and to allow them to define the problems as they see them in their classrooms.

Leder's presentation on mathematics education and gender provided interesting data on gender differences in participation and achievement. Leder found that males still tend to do better than females on higher order tasks, whereas females tend to do better on lower order tasks. Too, males were more likely to select advanced mathematics classes than females albeit this difference is being narrowed. An interesting point that Leder raises is What would mathematics be like had it been discovered by females rather than males? Would the problems in texts be different? Would its teaching be different had it been developed principally by females? Leder speculates that the "findings" of mathematics, e.g., theorems, would be essentially the same as those of today but that we might see mathematics as more of a social construction and as a subject that can be learned in a variety of shared activities.

All of these thoughtful presentations combined with numerous conversations with mathematics educators from around the world suggest to me that mathematics education is a quite different enterprise than when I attended my first ICME 20 years ago. The world has changed and is becoming smaller in many ways, and so we might expect mathematics education to be different as well. My recollections of ICME-3 are that mathematics education was essentially an "intuitive science" in that well-meaning mathematicians pondered what might be good for school children. Often their ponderings were insightful but, nevertheless, were largely anecdotal. Today, I see a much more sophisticated profession, not only in terms of what is being asked, but also in the means by which people are struggling to answer the questions. Research has become much more school based than was the case 20 years ago.

Perhaps the biggest difference that I have observed between U.S. mathematics educators and those from other parts of the world, particularly where English is not the native language, is the explicitness of constructivism. Mathematics educators from the U.S.A are much more likely to cite the writings of Von Glasersfeld, Bauersfeld, and Steffe as an epistemological basis for their research. I have found that other mathematics educators outside the United States still emphasize the individuality of the child and of the teacher and the importance of culture in defining what it means to do mathematics, but that their foundation is based less on the actual writings of the constructivists. This does not mean that there is disharmony but rather that the "international" mathematics educators have found other ways to express their orientations rather than citing the work of the aforementioned constructivists. It may be that they will eventually find their way to these same writings. But I frankly found it refreshing to see the various ways people have of expressing the notions of what might be called "humanistic" mathematics.

For me, this was a very interesting ICME. I learned much about the Spanish culture and something about life in Spain. That alone made the ICME trip worthwhile. But I also enjoyed the conversations with mathematics educators of "my era" who had seen various reforms come and go and who were quite reflective about the status of mathematics education. In some sense, we agreed that we were seeing much of the same as we went to the various lectures and working groups. On the other hand, I sense that today's mathematics educators are much more eclectic in recognizing the contributions from sociology and psychology in conceptualizing problems. I regard this as quite significant. I recall Freudenthal's "Ten problems in mathematics education" address that he gave at the 1980 Congress in Berkeley as he attempted to parallel Hilbert's famous ten problems in mathematics. My feeling is that mathematics educators would today consider the recognition of ten problems in mathematics education to be a naive categorization of the field and that the many questions of today defy solution in some absolute sense. Rather, the field is realizing the complexities of the problems, is thinking relativistically not dogmatically, is recognizing that what pertains to one culture may or may not pertain to another, and that no single answer is appropriate for any particular question. To me, this maturity is both exciting and comforting. It will be interesting to attend future ICMEs to assess how this maturity contributes to improving mathematics education for teachers and students all around the world.

Frances R. Curcio

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I. Sessions I Attended

A. Working Group 14 on linking mathematics with other school subjects

I attended the four sessions of Working Group 14 and participated in the statistics subgroup. I presented a paper on building a theory of graphicacy--where are we now?, co-authored with George Bright and Susan Friel. I accepted an invitation to chair one of the subgroup sessions because Rolf Biehler, sub-group chair (Germany) had to attend another session.

B. Topic Group 26 on international comparative investigations

I attended one of the sessions of this topic group.

C. Plenary and regular lectures

I attended the opening session, specifically Anna Sierpinska's presentation on Whither mathematics education? I also attended several regular lectures—Christine Keitel on teaching math's anxiety, Kath Hart on what responsibility do researchers have to mathematics teachers and children?, and Alba Thompson on conceptual and calculational orientations in teaching mathematics.

II. Content of the Working Group and Topic Group Sessions

A. Working Group 14, Subgroup on statistics

Chief organizer, Fred Goffree (The Netherlands) indicated seven linking modes to be addressed by the speakers in the working group. The seven linking modes included:

- application (you already know the mathematics you need);
- investigation (you try to use the mathematics you know);
- mathematization (you find ways to use mathematics);
- problem solving (you know rules to use the mathematics you know);

- historical/genetical re-invention (you reconstruct the mathematics like people did in the past);
- phenomenological (you create the mathematics in a situation in which the mathematical knowledge explains the phenomenon);
- using informational technology and computers (using mathematical knowledge and knowing how to use the technology).

The presenters were challenged to address some key questions related to why we link mathematics to other subjects:

- Is it because we consider mathematics to be a tool rather than a discipline?
- Is it to enable students to apply what they know?
- Is it to make mathematics seem useful and therefore to motivate students to learn it?
- Is it because we think that by learning to apply mathematics in different situations it will yield improvements in the learning of the subject, or is it that the learning skills involved in applying mathematics across the curriculum are the same skills which are involved in the creating of new mathematics?

The 18 presentations were distributed among four subgroups: society and the environment, secondary education, statistics, and modelling (i.e., information technology and computers).

I was asked to summarize the proceedings of the statistics subgroup. I used chief organizer Fred Goffree's questions to organize my summary. I presented and discussed the following outline on the last day of the working group meeting.

1. Mathematics as a tool versus mathematics as a discipline

   Using statistics as a tool, mathematics helps us to understand the world. Statistics also helps us to understand the nature of mathematics; that is, mathematical statistics as a discipline.

2. Applications—dealing with data

Making sense of the world in our highly technological society requires that we interpret and analyze data. Using data to understand the world is highly motivational for students. Furthermore, data provide the greatest opportunity to connect society with mathematics, a by-product of which prepares better citizens.

3. Mathematics/statistics as processes

   Such processes include reasoning about phenomena and communicating about understandings.

4. Issues related to content and context were raised by all presenters

   Instructors must know their students to determine the appropriateness of presenting the content in various contexts.

5. Where do we go from here?

   We raised many questions for which there were no immediate answers. There are enough questions to keep us busy for the next four years—at least!

B. Topic Group 26

Chief organizer Gabriele Kaiser (Germany) explained the long tradition of comparative education—beginning with "travelers' tales" and oral reports and evolving to more systematic data collection about education in different countries.

Citing Postlewhaite (1988), she indicated that the major aims of comparative studies include:

1. Identifying what is happening elsewhere—what might help;
2. Describing similarities and differences in educational phenomena;
3. Estimating relative effects of variables on educational outcomes; and
4. Identifying general principles concerning educational effects.

Some major problems with comparative studies include:

1. Methodological problems; and
2. Ethnocentric bias in defining topics and theoretical assumptions.

Reasons for conducting international comparative studies include:

1. Explicit understanding of one's own theories of how children learn mathematics, questioning one's own traditional practices (e.g., Stigler); and
2. Identifying relationships between components of educational systems (e.g., Robitalle).

The limitations of international comparative studies include:

1. Measurement problems;
2. Understanding and defining curriculum;
3. Gender influence;
4. Large-scale international studies versus smaller regional studies;
5. Role of global cooperation;
6. Impact on national educational systems; and
7. Analysis of classroom reality.

Following the opening session of the topic group, I attended Lianghuo Fan's presentation on a comparative study of American and Chinese textbooks concerning the applications of arithmetic. Questions he addressed in his study are: "Why do we need applications?" and "How are applications presented?"

III. What I Learned at ICME-8

This is very difficult to capture in such a small amount of space. In summary, I learned about other statistical studies being conducted in Australia, England, and Germany. I received constructive feedback on my presentation that will help George Bright, Susan Friel, and me to make revisions as we prepare our manuscript for publication. Finally, I was enlightened by information related to the international comparative studies. This will be useful to me as I complete my collaborative work with Prof. Natalia Stefanova (St. Petersburg State Pedagogical University, Russia) entitled, "A qualitative comparative analysis of two grade five classes: New York City, U.S.A., and St. Petersburg, Russia," recently funded by New York University.

It is always informative to listen to our international colleagues and to share ideas related to improving the teaching and learning of mathematics; and, it is always so interesting to see how our similarities outweigh our differences.

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I. Sessions I Attended

Besides the four plenary sessions, I concentrated mostly on my participation in Working Group 26 on connections between research and practice in mathematics education and Topic Group 6 on mathematics teaching from a constructivist point of view. I also attended several regular lectures by D'Ambrosio on ethnomathematics--where does it come from and where does it go?, Keitel on teaching math's anxiety--a circulus of aversion to mathematics with teachers and students, Gjone on a new role for curriculum documents--from inspiration to production plans, Gerdes on culture and mathematics education in (southern) Africa, and Skovsmose on critical mathematics education--some philosophical remarks. Finally, I attended the session reporting on the ICMI study--what is research in mathematics education and what are its results?

II. Content of the Working Group and Topic Group Sessions

In Working Group 26 the discussion focused on the connections between research and practice in mathematics education. The speakers (Jaworski, Dawson, Gonzalez, Poli-Mignoni) delivered brief and controversial addresses to the audience inviting the participants to consider issues such as the role of teacher research in bridging the gap between research and practice, the need to support teachers involved in teacher research, the impact of teacher research on theory building, the impact of large scale research on teaching practice, the impact of theory on practice, and mechanisms needed to involve teachers more actively in the dialogue about mathematics education.

Discussions about connecting research and practice often result in the community of academic researchers thinking of ways to "translate" theory in ways that make it more comprehensible to teachers. Fortunately, in this working group the discussion focused on creating mechanisms for accepting teacher-research as a form of scholarship and accepting teacher-research as part of the process of generating the knowledge base about teaching and learning. These two issues were controversial among the working group participants, and much time was spent on the debate of these particular points. The following questions are examples of the questions addressed during the small group discussions: What is the nature of collaborations among teachers and researchers? What is the nature of inquiry projects that teachers pursue? What support mechanisms are needed to support teachers who conduct research in their classrooms and with their students? What are the political implications of teacher-research in countries where there is little freedom of choice for curricular materials? To what degree are teachers' voices considered in large scale studies conducted around the world? How do large scale findings impact practice? How does practice impact the generation and revision of theory? How can teachers' voices become a part of the conversation about mathematics teaching and learning within the community of mathematics education? How can we integrate theory and practice in preservice education? What experiences in preservice education facilitate the development of a future teacher-researcher? Can, and is it necessary that, all teachers become teacher-researchers? While there is no easy answer to any of these questions, the discussion and the varying perspectives of the participants provided a rich backdrop for the work of Working Group 26.

The papers presented in Topic Group 6 were about mathematics teaching from a constructivist perspective. The most interesting controversy arose when the question about whether there is such a construct as constructivist teaching was addressed by Maher. As was expected, different speakers took different positions on this issue. The audience was quickly drawn into this debate. Another well articulated question about teaching within the constructivist perspective was raised when Jaworski addressed the dilemmas faced by teachers as they decide when, or how much, to tell students about the mathematical ideas the students are investigating and exploring. The speaker suggested that the classroom tensions raised in teaching within a perspective were best resolved by exploring and researching classrooms' social climates. According to Jaworski, classroom-based research, or research into practice, can provide insights into the theoretical debates and can, in fact, rationalize the polarization between theoretical perspectives. The perspectives of Varelo added to the discussion the question of how mathematics teaching at the college level may take a more constructivist approach. She specifically addressed the resistance of college students to a constructivist approach to teaching mathematics. This resistance results primarily from the students' constructed understanding of the nature of mathematics teaching and learning.

III. What I Learned at ICME-8

The international perspectives on issues in mathematics education always constitute a rich learning experience. I was particularly interested in the recent developments of research in mathematics education in countries like Brazil, Spain, and Portugal, since the attendance of researchers and teachers from these countries was higher at ICME-8 than at previous ICME meetings. It is especially interesting to see how so many of the issues that we address in the U.S. seem to be of concern internationally. For example, Portuguese participants were distraught with recent press releases of standardized test results for mathematics in their country. Of course, such devastating publicity will result in grave implications for the reform initiative in that country. In spite of the similarities of issues among countries, the perspectives on change are very different and the approaches taken towards reform vary greatly. Working Group settings are very beneficial for this international exchange of experiences. I learned more about countries and their mathematics education scenario in the more informal setting of the Working Groups than in any of the more formal regular lecture formats.

Teacher-research is a focus of my work and participation in Working Group 26 was very beneficial. All of the questions addressed in section II above are questions that permeate my work. I was particularly interested in the various projects internationally that involve preservice elementary or secondary teachers in research experiences. The goals of these projects are to develop an inquiry disposition in future teachers so that they realize that research is an important component of the lives of teachers. The biggest struggle that most projects face is in finding mentor teachers who are themselves researchers to work with the future teachers. The most successful experiences are the ones that have an inservice and a preservice component for professional development, both focusing on teacher-research.

The lectures by Skovsmose, Gerdes, and D'Ambrosio reaffirmed the role of ethnomathematics in the research agenda of many countries. Although their approaches are quite distinct, these three scholars engage in the discussion of critical mathematics education, cultural issues in mathematics education from a critical perspective, and ethnomathematics as a theoretical framework for mathematics pedagogy involving cultural and societal issues. In all cases the socio-cultural and political context provide the basis for educational decision-making. Gerdes' examples of curriculum development in Mozambique generated much debate. Several participants from African countries in attendance at his lecture were highly critical of the ethnomathematics approach to mathematics teaching that Gerdes presented. Others, also from Africa, were supportive of the approach pointing to the empowerment of learners as they engage in the critique of the social context of their countries as a form of education for social transformation. By contrast, the examples given by Skovsmose were carried out in a highly technological society. Skovsmose proposed a thematic approach to promote critical thinking and reflection. He described energy as a sample theme and described the lessons that might emerge as the teachers and students explore the theme. In this approach, mathematics was used as a tool for students to understand the world around them and, in particular, the problems related to energy in the exploring the context of farming.

I also took advantage of the exhibits to become acquainted with the publications from many countries and from many different national organizations of mathematics teachers. Part of the Casio exhibit was the video tape of the interview with Paulo Freire which was very enlightening and informative as Freire interpreted mathematics education within his theoretical perspective. In general the meeting was very productive as I established new professional contacts internationally and reestablished old acquaintances.

Helen M. Doerr

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I. Sessions I Attended

I attended three plenary sessions: A. Sierpinksa onWhither mathematics education?, David Tall on information technology and mathematics education--enthusiasms, possibilities and realities, and Jan de Lange on real problems with real world mathematics. I attended the sessions of Working Group 15 on the impact of technology on the mathematics curriculum and Topic Group 17 on mathematical modelling and applications. I also attended the following regular lectures: A. Sfard on metaphors and models for conceptual change in mathematics, T. Cooney on conceptualizing the professional development of teachers, G. Vergnaud on important cognitive changes in the learning of mathematics--a developmental perspective, O. Skovsmose on critical mathematics education--some philosophical remarks, A. Thompson on conceptual and calculational orientations in teaching mathematics. In addition, I presented a poster session on investigating exponential functions with a graphing calculator--some limitations of the technology.

II. Content of the Working Group and Topic Group Sessions

Working Group 15 began with a plenary session followed by the meetings of three subgroups, software demonstrations, and closing remarks by three reactors. The plenary talks addressing curricular changes in the technological era--a framework and perspectives were given by P. Thompson and C. Laborde. The three subgroups were: (1) modeling and real-life applications, organized by Koeno Gravemeijer of the Freudenthal Institute in the Netherlands; (2) organizing curriculum around big ideas, organized by Daniel Chazan of Michigan State University in the U.S.; and (3) novel content with technology, organized by Al Cuoco and Paul Goldenberg, of the Education Development Center in the U.S. I participated in the first subgroup, where the following papers were presented:

Connecting time and space--using technology in mathematics

Marge Cappo, Learning in Motion, U.S.

Context situations and models in learning to add and subtract

Frans Van Galen, Freudenthal Institute, The Netherlands

The evolution of students' mathematical meanings while acting in a computer microworld

Janet Bowers, Paul Cobb, Kay McClain, Vanderbilt University, U.S.

Technology environments for middle-school--embedding mathematical activity in design projects

Judith Moschkovich, Institute for research on learning, U.S.

Constructing ways of mediation between mathematics and reality through the use of a spreadsheet

Joao Filipe Matos, Centro De Investigacao Em Educacao, University Of Lisbon, Portugal

Each of these five papers addressed particular aspects and perspectives on modeling and real-life applications.

I also participated in Topic Group 17, which began with a general session with opening talks given on mathematical modelling as part of the school curriculum (Henry Pollak); Brazilian research in mathematical modelling (Dario Fiorentini); and mathematical contest in modeling and the teaching of mathematical modeling (Qi-xiao Ye).

The subgroup session in which I participated had two talks: one on mathematics at school and in reality by Hans-Wolfgang Henn (Germany) and the other on an integrated approach to mathematical modeling by Helen M. Doerr. In this latter talk, I discussed the typical use of computer modeling in the secondary curriculum involving the manipulation of a previously built model (an expert's model) within some set of parameters. What is less well-understood is the potential effectiveness of engaging students in the actual process of building models using computer-based tools. In this secondary classroom study, we have investigated the construction of understanding of the motion of an object down an inclined plane which takes place through the process of model building. The three significant components of the modeling process explored in this study are the action of building representations and relationships from physical phenomena, the use of a simulation environment to explore conjectures, and the iterative process of developing and validating a solution through the use of multi-representational analytic tools. Beginning with a physical setting, students gather data and conjecture potential relationships between quantities. Through systematic inquiry and the coordination of multiple representations including those in a simulation environment, the students explore, refine and validate a solution to the posed problem. This study was designed to understand how these components are interrelated.

III. What I Learned at ICME-8

Several interesting themes emerged from across the five papers presented in subgroup 3 of Working Group 15 on the impact of technology on the mathematics curriculum. In these papers, we find that much larger "chunks" of curriculum are being addressed in the work that is done in the classroom. The papers by Bowers et al, Cappo, and Moschkovich, in particular, presented curricula approaches that were not add-ons to existing curricula, but rather more significant reformulations of the curriculum. In addition, the level of analysis that was done was at the level of the whole class. Thus, rather than looking at just the knowledge constructed by individual learners or learners in small groups, there were attempts to come to understand how the class as a whole began to share in the knowledge that emerged from the engagement with the curricular activities. It was particularly interesting to see the attention which was paid to qualitative arguments and discussion about mathematical ideas by students.

Another theme that emerged from these five papers was the issue of whose model was it that was being explored or created and where is the mathematics in relationship to that model? It is far beyond the scope of this brief report to address what was meant by a model and how the mathematics came to be understood in terms of the model, but the contrast among the papers was intriguing from this perspective. The mathematics of the models in the Cappo and Moschkovich papers, for examples, was in some ways explicitly hidden, keeping more complex issues below the surface while providing an opportunity for students to explore more visible questions. In de Matos' work, on the other hand, the student made much explicit use of their mathematics in creating spreadsheet solutions to posed problems. The work of Bowers et al and Van Galen suggested that students could engage in creating new mathematics through their interactions with the tools.

In her paper, Sfard contrasted two metaphors for learning mathematics: the acquisition metaphor and the participation metaphor. She described the acquisition metaphor as having been the dominant metaphor for research in mathematics education, with its concomitant emphasis on and language of entities such as knowledge, idea, notion and concept, and actions such as reception, acquisition and construction, and teaching as delivering, conveying, and facilitating. She contrasted this with the participation metaphor where there are no entities, knowledge is replaced by knowing, and activities are never considered separate from context. She then argued that because of the metaphorical status of theoretical frameworks, it is possible to combine these frameworks, bringing to the fore the advantages of each.

In his presentation, Vergnaud discussed the nature of cognitive processes. He described meaning as being in schemes, which he characterized as a functional dynamic totality. A scheme is characterized by the invariant organization of behavior (that is, activity, representation, and perception) for a certain class of situations. Hence, an algorithm can be viewed as a scheme. Schemes are also made up of operational invariants, including goals, expectations, anticipations, rules of action, information seeking, control and inferences. Vergnaud defines a concept as consisting of a situation, a set of operational invariants, and a set of linguistic and non-linguistic symbols.

Skovsmose addressed several philosophical issues from the perspective of a critical mathematics education. A central point in his presentation was to problematize mathematics education in the first place. His argument was that mathematics is a problematic tool, claiming that most of the means of achieving both the wonder and the horror of science and technology rests on advances in mathematics. Hence, the study of mathematics is itself also problematic. He offered two central tenets following from this. First, that reflective knowing is more than mathematical understanding. The focus of mathematics education can not be on the development of concepts only. Rather, reflective knowing must also consider fostering a critical view on the part of students, asking questions: How reliable are these formulas? What does it mean (in the particular example on energy that was presented) if the velocity is zero? What are some other things that it might be important to consider? Second, it is important to consider examinations where everyone passes. In this discussion, Skovsmose made the claim that there could be examinations without having students re-cycle through grade levels. He asked the question of how this situation has come about and claims that passing/failing is not in the nature of examinations but rather in social structures.

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I. Sessions I Attended

I attended many excellent lectures at ICME-8, including lectures by T. Carpenter, G. Howson, T. Cooney, D. Robitaille, G. Jones, A. Sierpinska, K. Hart, M. Guzman, G. Kaiser, J. Dossey, A. Millet, M. Briggs, T. Cooper (for A. Heirdsfield), C. Kieran, and G. Leder.

II. Content of the Working Group and Topic Group Sessions

I participated in Working Group 12 on elementary mathematics curriculum and split my time between the international comparisons (Topic Group 26) and technology (Topic Groups 18 and 19). Rather than just summarize presentations and list points made by lectures or participants, I also list and briefly discuss some of what I consider some of the most important issues presented and discussed and how these issues cut across the working and topic group sessions.

The working group issues, discussion, and papers can quite easily be divided into those that focused primarily on content issues and those that focused more on teaching and teacher change issues with regard to existing and future curriculums. From the discussions and papers it was clear that many countries have recently developed standards (frameworks, guidelines) to guide curriculum development in their respective countries. It was equally clear that implementation of standards and frameworks was a slow and often difficult task across countries. In some cases, the content of the recommended curriculum was questioned. Sometimes this involved issues of whether something should be included at all and sometimes it involved questions concerning the appropriate grade placement. Notions of intuitive probability is one example of such content that surfaced in the working group discussion. Other issues common across countries centered on implementing parts of curriculum frameworks that centered on developing student thinking and higher-order reasoning. In England and Wales, for example, this is (was) frequently attempted through the use of small group work with a heavy emphasis on the use of projects and investigations. Currently, there seems to be some negative reaction to these changes. The extent of this backlash is difficult to accurately measure, but it does seem that in some communities there has been a return to more whole class work. Some of the pressure for this change has come from teachers and some from parents.

The issue of representing mathematical ideas and the development of related notion (and related questions such as when to introduce notation and how to introduce it) surfaced regularly in the working group. This issue was quite important because a strong point was made in the working group about the value of teachers using students' informal solution methods as part of their teaching. Thus the question of how students should represent their methods for reporting and discussion purposes naturally arose. This issue, not surprisingly, was not resolved. There were participants who felt that students could and should create and use their own notational schemes initially. Others felt that it was much easier and wiser to move to more formal and regularly established methods and schemes early on.

Technology issues and discussions were a part of the working group discussions as well as at the center of the technology topic group. Several issues were central to these discussions. First, the issue of equity is important. In general, the use of technology is expensive. Thus, there is and will likely continue to be wide discrepancies between schools and between students in their access to technology. The questions that naturally arise seem to center on whether opportunities should be limited to those that can be provided for all schools and all students, or whether the opportunities should be maximized for students and schools while being ever mindful that everything possible must be done to minimize inequities. Again, the issue was not resolved but everyone was appropriately sensitized to it.

Another issue that arose was whether technology resources should be focused on specific purpose software or on providing general tools for students and teachers to use. Specific purpose software is software designed to teach and/or develop a specific idea, and often it does not have lots of general applications. For example, the software might focus on developing student ability to determine equivalent fractions. General purpose tool software, on the other hand, includes things such as construction tools (e.g., Geometer's Sketchpad), spreadsheets (e.g., Excel), graphing programs, data bases, and word processors. Some very interesting applications of both types of software exist and are being developed. My own observation is that the use of general tools software probably makes more sense in an environment of very limited resources.

The international comparisons topic group sessions were very interesting but unfortunately one had to choose from a number of interesting options. I chose the subgroup on TIMSS, the Third International Mathematics and Science Study. The details of the TIMSS sample and data collection were carefully described and summarized. Rather than reiterate these details, let me state some of the issues that I think are important. In my view, those who wish to find fault with the data will have the same arguments available as they had with the SIMS data. Namely, the use of teacher self-report data to detail the curriculum, in particular student opportunity to learn, is quite clearly fallible, yet it is still the central means of characterizing opportunity to learn in TIMSS. Also, the allowance for replacement schools in the original sample by some countries will be used to call into question the validity of the results. I think this argument has some merit.

III. What I Learned at ICME-8

One of the most striking things I relearned from ICME-8 was the similarity in problems faced in mathematics education across countries. Differences of opinions about what to teach and how to teach it are not limited to the U.S. The issues are dealt with differently across borders, however. In many countries the diversity that exists in America is not possible because of the existence of a detailed national curriculum and a very formidable national testing system.

It was good to exchange ideas, meet new colleagues, and to rethink many of the things that are often taken for granted when one speaks most regularly with those who have a similar background and perspective. Thanks to the Arrangement Committee, NCTM and NSF for the opportunity to expand my horizons.

Peggy A. House

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Marquette, Michigan

I. Sessions Attended

Sessions I attended at ICME-8 included two opening plenary lectures, one on Whither mathematics education? by A. Sierpinska, Canada, and the other on the role of the mathematician in mathematics education" by M. de Guzman, Spain; two closing plenary lectures, one on information technology and mathematics education: enthusiasms, possibilities and realities by D. Tall, United Kingdom, and the other on real problems with real world mathematics by Jan de Lange, Netherlands; several regular lectures, including the changing face of school algebra by C. Kieran, Canada; conceptualizing the professional development of teachers by T. Cooney, U.S.A; mathematics and commonsense by G. Howson, United Kingdom; perspectives on teaching geometry for the 21st century by V. Villani, Italy; and others; and presentations within Working Group 21 (the teaching of mathematics in different cultures) and Topic Group 2 (secondary school mathematics). Other activities included commercial and non-commercial exhibits, poster presentations, and discussions.

II. Content of Working and Topic Groups

Of particular interest to me were the discussions within Working Group 21 on the teaching of mathematics within different cultures and the subgroup on the preparation of teachers to teach to diversity.

B. Barton, New Zealand, set the stage for the working group with his discussion of "socio-cultural nets" and his graphic metaphor of a spider's web. The web gives the spider access, but also restricts and defines its boundaries; the web has many different functions, some of which are unexpected; the web can be changed and extended, and it can be broken. In a similar manner, nets are frameworks in which individuals make meaning of their experiences. Language, Barton noted, is one of the nets that individuals possess; mathematics is another such framework for knowledge.

These webs or nets are specific to each individual, and when there is interaction between individuals, as between teacher and student, their nets must coincide sufficiently to permit each to understand what the other is saying and respond in a recognizable way. The more similar the nets, the easier the communication and the stronger the resulting learning. Individuals who share culture usually possess nets of similar weave; and although each net is unique, the similarities in their structures act positively to facilitate communication. In this context, then, education can be viewed as a type of web-building, and teachers in the multicultural classroom face the heightened challenge of disentangling and connecting with a variety of webs, some of which may be quite dissimilar to their own.

Barton's metaphor was useful in helping to shape the discussions that followed, in particular those that focused on the preparation of teachers. Presenters identified factors that exacerbate cultural conflicts in the classroom and attempted to characterize a "culturally responsive pedagogy" that is marked by unconditional acceptance of the learner, commitment to academic excellence, advocacy-oriented assessment, and a classroom culture of inclusiveness.

Among the issues that impinge on teacher preparation are several commonly held beliefs and expectations that need to be exposed and examined. For example, teachers may expect certain groups of students to be "different" (for example, racial or ethnic groups), yet fail to see either the differences among individuals within the group or the similarities across groups. An example was presented of a group of preservice teachers who, on the surface, appeared to be quite homogeneous; yet when presented with a geometry problem, the 24 individuals in the class saw the problem from 13 distinctly different perspectives. In retrospect, the most important lesson for the preservice teachers was the realization of the differences among the members of the class and the recognition that a teacher who viewed the problem from the vantage point of one "web" only could easily fail to connect with students whose understanding was anchored in very different structures.

Another point of divergence between teachers and students, especially students of diverse cultures, is observed in what teachers assume to be "significant" or "authentic" mathematics for the pupils. Studies revealed that the examples of "authentic mathematics" that pupils created were very different from the examples of real-world applications selected by their teachers. The need to help teachers develop the ability to choose and guide significant mathematical tasks that are also relevant or "authentic" to their students is another dimension of the teacher education challenge.

It is also important to recognize that culture is not the same as ethnicity, and it is an oversimplification to equate multiculturalism with groups (such as females, ethnic groups, etc.). It is true that certain cultural traditions, values and customs are stronger in some groups than in others—for example, some place a high value on cooperation while others reward competitiveness—yet it is individuals within those groups that must be the teacher's concern. At the same time, cultural differences have been shown to be related to differential learning outcomes (e.g., underachievement) of students in certain groups, and this has the potential to contribute to certain assumptions, negative stereotypes, and lowered expectations for members of those groups. Teacher preparation must devise strategies to enable teachers, not to remove cultural differences, but to accept and affirm those differences and use them as a resource for teaching. Presentations and discussions within the group went on to describe efforts to achieve that goal in a variety of settings in Korea, China, Brunei, Brazil and the United States.

III. Learning at ICME-8

As was the case in previous ICMEs, I am always most impressed by the commonality of our problems and concerns across nations. For example, the issue of multiculturalism exists in one form or another in virtually every country. Perhaps we in the United States, having become accustomed to the "melting pot" description of our society, may assume that other countries do not share our concerns or our problems; yet discussions and presentations at ICME-8 described situations throughout the world in which educators are struggling with the shared challenge of effectively reaching minority or multicultural groups of one description or another. Likewise, the challenges of preservice and inservice teacher education are widely shared—for example, how to develop and deliver professional development programs that are coherent, content-rich, and sustained over a significant period of time rather than one-shot, something-for-tomorrow-morning activities. We share concerns about the most effective use of technology in mathematics education and the accompanying issues of equity in access to such technology. We struggle with challenges of implementing effective assessment as well as effective pedagogy. Curriculum revision, distance learning, gifted students and students with special needs, problem solving, translating research into practice, and mathematical connections are just some of the topics that know no national boundaries. In summary, the greatest value of the ICME experience is the realization of our connectedness with colleagues from throughout the world with whom we share values, goals, and aspirations.

Victor J. Katz

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Washington, DC

I. Sessions I Attended

I attended all four sessions of Working Group 19 on preparation and enhancement of teachers, and one session each of Topic Groups 16 on history of mathematics and the teaching of mathematics, and 8, proofs and proving: Why, when and how—because I was giving a presentation in each of those groups. I attended the plenary lectures of Anna Sierpinska, Miguel de Guzman, and David Tall. I attended the regular lectures of Anna Sfard, Christine Keitel, Luis Puig, Paulus Gerdes, Peter Galbraith, and Maria Bartolini. I attended all three sessions of the International Study Group for the Relations Between the History and Pedagogy of Mathematics (HPM). Finally, I visited a few project presentations and posters.

II. Content of the Working Group and Topic Group Sessions

Working Group 19: The working group consisted of several brief presentations on new ideas in teacher education from researchers in various countries, followed by two days of conversations among participants in which common problems were discussed. There were three major areas covered: Mathematics teacher knowledge and teacher beliefs, mathematics teacher education and information technologies, and mathematics teacher education programs. Presentations on the third aspect showed that those involved in teacher education throughout the world are actively exploring new ways of preparing teachers, especially elementary teachers. Everyone seems to have the experience that preservice elementary teachers are weak in mathematical skills and are very math anxious. And so programs are being developed to change attitudes, partly by having students working on interesting problems, partly by requiring that they actively participate in classroom activities, partly by involving them in the already existing community of schools and teachers. New technological innovations include preparing CD-ROMs intended to improve the mathematical discourse abilities of elementary teachers and using the Internet to deal with inservice programs for teachers unable to attend regular classes. Finally, discussions involving the first aspect showed that there is a growing consensus on what mathematics knowledge elementary or secondary teachers should have, but there is no clear vision of how prospective teachers should gain that knowledge.

Topic Group 16: In the session I attended, there were presentations by delegates from four different countries dealing with how history is being used in the classroom at four different levels: in elementary schools, secondary schools, preparatory schools (France), and colleges (U.S.). All of the presentations reported success in using history, but there are as yet few studies documenting this success in any scientific way. My own presentation dealt with my work at the Institute in the History of Mathematics and its Use in Teaching, of which I am the co-director. The second session of this topic group considered the question of the use of history from a theoretical viewpoint.

Topic Group 8: The first session dealt with some general issues of the use of proof in the classroom. The session I attended was on the role of proof. There were presentations dealing with the changing nature of proof through the years, the role of proof in developing understanding, how students relate proving to explaining, the need for consideration and reflection with students being introduced to proving, and (my own presentation) the history of proofs by mathematical induction and its implications for teaching.

III. What I Learned at ICME-8

The central lesson of ICME-8 is that there are many bright people all over the world considering how to improve mathematics teaching and, especially, how best to prepare the next generation of mathematics teachers, but that there is no magic bullet which will enable everyone to learn mathematics painlessly. Most people, however, are optimistic about the future, because most innovations, at least initially, do have success with students, including prospective teachers. The problem everyone finds, however, is institutionalizing new methodologies.

Christine Keitel, however, was more pessimistic. She has found that mathematics anxiety remains a serious problem, even with prospective secondary teachers of mathematics who have no real trouble learning the basic material and passing exams. Her research over the years, using questionnaires, essays, interviews, etc. seem to show that many future secondary teachers are attracted to mathematics because they dislike uncertainty or ambiguity; they have been taught that if they follow the rules, they will get the correct answer. And so they continue to present mathematics to their own students in the same way. Thus the attempt to broaden mathematics teaching to include explorations, multiple approaches, discovery, etc. are proving difficult for these teachers, who will naturally share their anxiety with their students. Unfortunately, Keitel does not have very many suggestions for combating this problem other than a continued attention to the use of modeling as part of teaching at all levels.

Despite Keitel's pessimism, most of the other lectures and presentations were more upbeat. Paulus Gerdes, for example, reported on how his prospective teachers were working with mathematics problems derived from interests of their own communities in Mozambique and were having more success in introducing mathematics to students who are first in their families to attend school at all. And Maria Bartolini showed how the use of classical drawing instruments has been improving the teaching and understanding of geometry in some schools in Italy. Her talk showed why, despite the advantages a careful use of new technologies affords us, one should not neglect old technologies; they still are useful in developing mathematical understanding.

David Tall, in fact, worries about whether newer technologies will eventually make mathematics teachers obsolete. He gave a brief overview of the increasing capacities of computers over the past two decades and how these have been absorbed into the classroom at various levels. But he noted that even though each new technology presented cognitive advantages for students, there were always accompanying disadvantages. He concluded, fortunately, that there will always be a role for mathematics educators; the reality of the classroom, with so many different types of students, will always require the reflective guidance of an informed professional.

My own major interest at ICME-8 was the sessions of HPM. As always, the presentations, by delegates from around the world, were varied and exciting and gave me much to consider. Many people are carefully considering how history can be used in the classroom, and it is clear that, like any innovation, the successful use of history requires a good deal of thought and experimentation. One must consider, for example, how "accurate" the history needs to be. Being absolutely faithful to history often causes rather than solves pedagogical problems, because real history involves many twists and turns and dead ends. Further, the use of historical material often requires that students be familiar with the cultural context out of which the mathematics grew, because an ancient understanding of a concept is not identical with a modern one. It is often not possible to share the entire context, so the question becomes one of careful choice of material and its use. On the other hand, there are numerous "stories" which have grown up around the history of mathematics which are in fact myths. Should one use these with students, because, after all, these myths are often easily remembered and are part of our mathematical folklore? Under some circumstances, these myths may, in fact, be useful in pedagogy, but again one must be careful. To be successful with the use of history, the teacher, it is clear, must have a decent understanding of the accurate history and must be able to know enough about the mathematics as well to be able to choose how and where to use historical material. In particular, the teacher must be familiar with the growth of mathematical ideas all around the world, so choices appropriate to the particular class can be made. Those of us in HPM have the major tasks of convincing the mathematical community as a whole that the use of history in the classroom is essential for good mathematics teaching, of making sure that appropriate materials are available in whatever technology is available, and of showing how one can use this material to enhance the learning of mathematics in our students.

Glenda Lappan

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East Lansing, Michigan

I. Sessions I Attended

I was the chair for Topic Group 2 on secondary mathematics education, 7–12, and team leader for the participants in Working Group 19 who were interested in middle school mathematics education. In addition, I attended the opening session of the conference and heard Anna Sierpinska of Canada and Miguel de Guzman of Spain. Additional plenary talks I attended were given by Carolyn Kieran, Alba Thompson, Pat Campbell, David Moore, and Geoffre Howson. The evening cultural session on Sunday and the trip to Jerez were also occasions for professional contacts as well as were the poster sessions.

II. Content of the Working and Topic Group Sessions

Topic Group 2 focused on research and development issues in the areas of curriculum, instruction, assessment and the alignment of these aspects of secondary mathematics education. The presentations and discussions focused on work that helps illuminate questions such as the following: What is the interaction between new curricula, new instructional strategies, new assessment strategies and the professional development of teachers? What are the "big" ideas in mathematics at the secondary level and what are compelling contexts that give students access to these ideas? What are the most important research questions that need to be answered to guide change in curriculum, teaching, and learning over the next decade? What are the issues of articulation between secondary school and primary school? Between secondary school and higher education? Between secondary school and the world of work?

The first session of the topic group was devoted to two plenary talks and two reactors to these talks. Jan de Lange from the Netherlands gave the first talk in which he emphasized that all over the world mathematics educators are struggling with many common issues. He put forward the following as an important set of issues in teaching and learning in many countries: Problem solving, thinking/reasoning, integration, technology, visualization, flexibility, and learning environment. Zalman Usiskin from the United States gave the second plenary talk which he organized around four big ideas that have to be considered in attempts to improve school mathematics: applications, skills, representations, and structure. He made a strong case that mathematics is not just arithmetic. There are other very useful areas of mathematics that school students deserve a chance to study. He also reminded us that mathematics does not have to be hard to be good!

Peter Sullivan from Australia was the first reactor and reminded us that the perceptions from outside the mathematics education community—parents, administrators, teachers of other areas, and business and industry—matter very much in what we are or are not able to accomplish. The main question from other stakeholders is, "Are schools really doing any better?" He also raised the issue that although both speakers and many others in the conference talk about the importance of excellent, real problems in the curriculum at all levels, we do not have good ways of sharing examples. Dirk Janssens from Belgium was the final reactor and made the strong case that what matters in implementing reform is what is meaningful to the students. Realistic problems may have no mathematical meaning for the students. This new teaching around big problems may be so demanding that teachers return to an easier more mechanistic way of operating in the classroom.

The second session of the topic group had four presentations from four long-term research and development curriculum projects: Glenda Lappan from the Connected Mathematics Project of United States talked about issues of teacher learning from new instructional materials. Rina Hershkovitz of the Weizmann Institute in Israel talked about the teaching and learning process in an interactive computerized environment. Koeno Gravemeijer of the Freudenthal Institute in the Netherlands talked about the tension between guidance and reinvention in the creation of new materials and in new instructional practices. Brian Greer of the Oxford Mathematics Project in England talked about the extent to which text materials by their design can encourage and contribute to the establishment of effective teaching-learning environments.

Working Group 19 was on the preparation and the enhancement of teachers. Marjorie Carss of Australia organized the group. After an initial meeting, the group split into a technology group and three other groups interested in elementary, middle and secondary teacher preparation and enhancement. The middle school group included about 20 people from all over the world. This was truly a wonderful opportunity to have an extended conversation with others who struggle in their own country with many issues that we face in the U.S.. This was perhaps the most personally satisfying experience of the week because we were able to raise an issue and talk about how each of us in our work deals with that issue. It was truly an international conversation among a group each of whom is involved in research and development around teacher preparation and enhancement.

III. What I Learned at ICME-8

Since I have already given some detail about the topic and working group meetings in the previous section, I am going to highlight the things that I took away from the plenary talks that I heard. In Anna Sierpinska's opening talk on Whither mathematics education?, she raised an issue that continued to be heard throughout the conference. She asked the question, "What do students learn from the results of solving their own problems?" Her response from her work is that they learn mathematical knowledge if the problems they have are mathematical. The question we have to tackle is, "How do we, as teachers, assure that students have mathematical problems?" In her work and in ours, there are examples of the mismatch between the teacher's idea of the mathematical potential of a problem and the student's approach to solution, which is playing a game to guess what operation(s) is (are) needed to satisfy the teacher. She also claims that the emphasis on communication raises two risks: the possibility that mathematical thinking requires not so much linguistics as a lot of imagination, and that often speech is silent. The internal conversation that students have may be very important.

Carolyn Kieran from Canada gave an excellent, well-organized talk, which was entitled, "The changing face of school algebra." She gave us a helpful definition of algebraic thinking: the use of any of a variety of representations to handle quantitative situations in a relational way. Then she gave an excellent overview of the kind of rethinking that is going on in many countries about school algebra. She contrasted the symbol view of the past with this new emphasis on algebraic thinking. After her many examples of work that is on-going, she summarized her position. She saw the changing face of school algebra as placing a greater emphasis on meta level activities, alternative representations and their related generalization activities and transformational rules. The challenge is to go in this direction while not losing the power of algebra, which to a great extent resides in its symbolic language.

Pat Campbell of the University of Maryland shared data from her five-year project called Project Impact. This is an amazing project that is having great success in improving the performance of low-socioeconomic status students in elementary school. The project's focus is on implementing a constructivist stance toward learning in the project schools. Each school selected agreed that all teachers in the school would be involved in the training and would work to implement the philosophy of the project. We have much to learn from this project. The whole school aspect and the nature of the support for teachers was clearly key in the results. Pat has been funded by the National Science Foundation to begin a similar project in the Baltimore Maryland Public Schools.

No one can as clearly articulate what statistics is about as David Moore from Purdue University. He took the theme technology-content-pedagogy in synergy and paired the three in every possible way and made a case that these concerns can speak to each other. For example, he defined the goal of the new pedagogy as developing flexible skills that are applicable to unfamiliar settings. He looked at the synergy between pedagogy and technology in this way: computing makes data analysis techniques available that go far beyond what a student can do by hand. The automation of techniques means that students can study more concepts. With simulation we have new ways of convincing, which means less emphasis on rigorous proof.

Geoffrey Howson spoke about mathematics and common sense in a delightful talk that started with a dictionary definition of common sense—average understanding, good sense, practical sagacity, the opinion of a community, the universally admitted impressions of mankind. He made the point that many students meet their own personal fault line in mathematics in about grade eight when they face multiplying negative numbers, at which point mathematics and common sense part. With his wonderful grasp of mathematical history, he quoted many mathematicians from the past that have pondered these same issues. For example, DeMorgan claimed the two expressions $\sqrt{-2}$ and –bare equally imaginary! Gauss did not publish his work on hyperbolic geometry because he was not prepared to listen to the cacophony of complaint at its absurdity. He went on to warn that we need to be careful in going too far with contexts since common sense approaches to solving real problems may drive out the mathematics. Mathematics relies on the structured organizing and sharing of common features. It begins in common sense but is more than common sense. He challenged us to use care in thinking about the teaching of mathematics and making sure that mathematics is not lost as we work to make it relevant to students.

Alba Thompson of the United States helped us to think about three aspects of the curriculum—the calculational curriculum, the curriculum of process, and the conceptual curriculum. She talked about characteristics of teachers that take a calculational stance in the classroom as opposed to a conceptual orientation. Her ideas give us a way to look at ourselves. Do we "speak in the language of number and number operations and set a tone that mathematics is about solving a problem to find a number solution?" Or do we ask questions that helps students to view calculations in a non-calculational , more generative way? Do we have an image of a system of ideas and ways of thinking that we intend for students to develop; an image of how these ideas and ways of thinking can develop in students; an idea about features of materials, activities, expositions and student engagement with them that can orient students attention in profitable ways; and do we expect and insist that students be intellectually engaged in the task and activities. What a worthy challenge!

Miriam A. Leiva

The University of North Carolina at Charlotte

Charlotte, North Carolina

I. Sessions I Attended

I attended the plenary lectures and international round table on the opening day of the congress and daily regular lectures. Throughout the week, I participated in Working Group 19 on teacher preparation and enhancement and also chaired a group that was formed initially as an informal subset of Working Group 19 on teacher preparation, but which proved to be the most valuable exchange of ideas for me in the congress and took the place of other activities. The lecture by Anna Sfard on metaphors and models for conceptual change in mathematics was particularly interesting to me among the rest of the program. Other congress activities introduced us to new colleagues and reacquainted us with "old" ones.

II. Content of Working Group and Topic Group Sessions

Given my interest in teacher preparation, I attended and participated in Working Group 19 on the preparation and enhancement of teachers. The group was so large that it was subdivided into three smaller groups even though the prepared abstracts were available to all. However, after the initial session, a rich discussion took place in the hall among group participants who wanted to focus more on teacher preparation, share concerns and questions, and reflect on various practices. I agreed to co-chair this fourth group with Phyllis Chinn, a colleague from Humboldt State University in California, with assistance from several colleagues from around the world. Topics that emerged as key to our discussion were:

- Important mathematics: Content
- Modeling and experiencing the visionary classroom: Pedagogy
- Models of teacher preparation programs
- Roles of mathematics departments and education faculty
- Linkages among teachers, schools, peers
- Assessment

Technology was discussed as a tool for instruction and not as a separate topic. The next section of this report focuses on a summary of the discussion generated and information shared in the teacher preparation group.

III. Teacher Preparation, Concerns and Practices Around the World

Eight countries were represented by twenty-one participants and contributors with discussion and responses focused in the topics described below. Common concerns were defined followed by a description of various practices identified here by country, where applicable, and an attempt to note commonalties and future directions.

A. Concerns – all participants and all countries

- What mathematics should be taught? How should it be taught?
- How much mathematics is appropriate?
- Who should teach the preservice teachers? Are all faculty qualified?
- Formal mathematics study does not imply understanding nor sense-making abilities.
- How to make connections between theory and practice, between mathematics in the university and mathematics in schools, among faculty, teachers and classrooms.
- Negative experiences in mathematics classrooms in students' education.
- Mathematics anxiety among preservice elementary teachers.
- Insufficient preparation in mathematics among preservice elementary teachers.
- Insufficient preparation in pedagogical concerns among preservice secondary school teachers.
- Insufficient background of curriculum by all preservice teachers.
- Support and linkages among mathematicians, mathematics educators, master teachers, schools.

B. Description of practices: Appropriate experiences mathematically and pedagogical in Teacher Preparation

- Projects and presentations to demonstrate creativity, content, delivery - United States

- Reasoning and proof; content selected to teach math and the teaching of mathematics to preservice teachers - Denmark
- Students reflecting on themselves and their work as "mathematicians." Thinking mathematically and experiencing mathematics - Canada
- Developing and implementing capstone courses - United States
- Practicing constructivism in the preservice classroom: Doing, talking, writing - Taiwan
- Preservice teachers "Replicating research" - Australia
- Relevant problems and an active classroom that is student centered-New Guinea
- Use the history of mathematics as a motivator of content and a tool for instruction - United States.
- Using applications and other appropriate content to teach, model, motivate.
- Linking faculty, preservice teachers in classrooms for school-based experiences and university content work - U.S.

C. Assessment practices in teacher preparation

- Portfolio and journals in mathematics and mathematics education classrooms.
- Various types of assessments including oral examinations one-on-one.
- Student-generated tests and other assessments tools in higher education.

D. Future directions and suggestions

- Encourage closer ties with mathematicians-mathematics educators to improve teacher preparation - Mexico
- Encourage better students to enter teaching - Yemen
- Review current practices in school-based experiences and advocate richer clinical practices for preservice teachers.
- Develop appropriate content guided by teachers' needs and aimed at strengthening foundation for their own future teaching. Preparation must include a strong mathematical background appropriate to level of teaching.

- Pedagogy guided by research about how students learn.
- University teacher not just as the lecturer but as the guide and facilitator.
- Faculty must have close ties to schools and teachers.

E. My own conclusions

It was reassuring to discuss common problems in teacher preparation with colleagues around the world and to identify mutual concerns. All participants had taken extraordinary measures to revise their own programs and these measures had a very familiar tone to me. They were congruent with the recommendations from the National Council of Teachers of Mathematics, Professional Standards for the Teaching of Mathematics, and with A Call for Change from the Mathematics Association of America. Finally, professional connections have been formed with colleagues in the teacher preparation group and further discussions are planned by mail and electronic connections in preparation for our next encounter in ICME-9.

Mary M. Lindquist

Columbus State University

Columbus, Georgia

I. Sessions Attended

Opening Session

Anna Sierpinska on Whither mathematics education?

Working Group 12 on curriculum changes in the primary school

Topic Group 16 on international comparative investigations.

Carolyn Kieran on the changing face of school algebra

Willibald Doerfler on means for meaning

Paul Cobb on supporting young children's development of mathematical power.

II. Content of the Working Group and Topic Group Sessions

Working Group 12 on curriculum changes in the primary school

The purpose of this working group was to consider the changing primary curricula, its content and its interaction with pedagogy and change. The plenary session, given by Thomas Carpenter, University of Wisconsin, primarily examined the role of notation in a changing primary curriculum. He illustrated how notation could afford or constrain children's solutions of problems, how notation could help show children's thinking and how notation could be an object of reflection. He challenged the working group to consider these three roles of notations along with three more general questions:

(1) How can curriculum be designed to provide children with an opportunity to build on their informal thinking?

(2) How can/should notation be introduced to support children's inventions?

(3) What role should students' invention of notation play in the primary mathematics curriculum?

The subgroup that I attended for two days had papers presented by Alison Millett, Graham Jones, Tom Cooper and Mary Briggs followed by discussion. Millett's case study focused on a primary school, working on its own, in implementing the curriculum recommendations of the National Curriculum of England and Wales regarding using and applying mathematics. Jones reported on probability curriculum research, responding to the increased emphasis on this topic by Australia, UK and U.S.A curriculum efforts. The grades 3-5 project was informed by a research-based framework describing elementary and middle-school students' thinking in probability. Cooper examined the role of instruction in influencing mental strategies used by students in grades 2-6 in Australia. The results suggest that students can develop their own strategies, but these tend to be subsumed once formal algorithms are introduced. Briggs characterized the differences between teachers who do and do not incorporate large numbers when working with young children. She noted that some primary teachers tended to be locked to national curriculum statements even though many opportunities arose to introduce large numbers. Nursery teachers and other pre-school teachers were not as prone to this practice, but she speculated that may happen with the advent of expectations for children prior to primary in the national curriculum. In essence, national curriculum statements could be a vehicle for constraining and even lowering teachers' expectations of students' mathematical thinking.

After reports from the subgroups, plenary talks given by John Dossey and Douglas Grouws helped us look ahead to implications of the Third International Mathematics and Science Study (TIMSS) and to the role of technology in planning primary curriculum. Dossey discussed how countries might make use of these data in terms of comparing their curricula for the primary grades to that of their international peers. Grouws focused on three issues: technology's possible influence on textbooks, the role technology in learning, and the equity issues associated with technology.

Topic Group 26 on connections between research and practice in mathematics education

The panel that opened this session gave a background of international studies ranging from a brief history of comparative education, reasons for comparative education studies today, to methodological difficulties and possibilities. The second day, I attended the subgroup that focused on TIMSS in which an overview of the current study was presented.

III. What I Learned at ICME-8

As with any congress, but especially with international congresses, it is often the interaction with colleagues that is the most beneficial. It is meeting a young Czech woman who gave me a beautiful book of Prague, but more importantly a written message about change. She reminded us that the public and many teachers are conservative, and that we need to persuade teachers and the public about the positive role of change. Yet, we should not conceal the negative aspects. It is the Chinese man who was so grateful that I wrote a letter to support his coming to the conference. Little did I know that he would not present, as had been requested, in the working group. It is the reminder of how many of our problems and our concerns are universal, or how other countries are struggling with a changing population of students and providing curricula and instruction to meet that change.

In our working group, I was struck by the struggle with change no matter from what vantage point you were considering. The questions that were raised early in the working group focused on administrators, politicians, and publics. For example, two of the questions were the following:

- How do we approach administrators/politicians about research results concerning children's thinking and the role it should play in the primary grades?
- How can administrators better support teachers in their work to engender mathematical ways of thinking in primary aged children?

The other questions focused on the role of teacher in students' learning:

- How do we assist students who are slow in inventing their own notation and slow in joining into the investigation of mathematical situations?
- What should be the role of children's thinking in the formal development of the school mathematics curriculum? How do we help teachers teach in this way?

One subgroup was held in Spanish and the issues they raised could well have been raised by teachers in the U.S. They centered on the need for positive motivation of teachers, for all to realize the change is slow and must be well planned, the role of the administrator is crucial but teachers must take a more active role, and teachers need the opportunity to work together.

No matter what country the person was from, it seemed that the need for change was assumed; although many commented that we are not always clear about why change is needed or, at least, do not clearly articulate those reasons to those involved in making change happen. The role of national curriculum guides or standards has caused countries to rethink not only the curriculum, but also many other political, instructional, and public relations issues. There was a caution from several individuals about the misinterpretations of national mandates.

I attended the international comparative studies topic group because of my involvement with the U.S. side of TIMSS and the National Center for Research's Board on International Studies of Comparative Education. This reinforced some of my own views about comparative studies and the concerns in the U.S. that are shared by those from many countries, but I gained little new knowledge.

Through the years that I have attended ICMEs, I have come to appreciate the difficulty of arranging such a congress. I realize how much easier it is now than eight years ago to arrange sessions due to e-mail; organizational correspondence at a distance for some has become fast and efficient. On the other hand, I was struck at how difficult it is to arrange working groups that are not narrowly focused and at the difficulty of communicating across the many languages. I believe the language problem will be solved with technology in the near future, but that serious attention will still have to be given on the best way to have sessions that are truly interactive and yet substantive.

Judy S. O'Neal

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I. Sessions I Attended

Day 1 included plenary talks by Anna Sierpinska on Whither mathematics education? and Miguel De Guzman on the role of the mathematician in mathematics education. Day 2 included regular lectures on mathematics teaching and learning for the future by Per Broman and transforming mathematics instruction in every elementary classroom--using research as a basis for effective school practice by Patricia F. Campbell, and evening sessions of the International Group of the Psychology of Mathematics Education (PME) and In Memoriam, Prof. Richard R. Skemp. Day 3 included regular lectures on some aspects in the teaching of mathematics at secondary schools in Switzerland by Urs Kirchgraber and new pedagogy and new content--the case of statistics by David S. Moore, and evening session perspectives on the teaching of geometry for the 21st century led by Vinicio Villani. Day 5 included regular lecture on issues in assessment--a never-ending story by Peter Galbraith. Day 6 included regular lecture on conceptual and calculational orientations in teaching mathematics by Alba Thompson. Day 7 included plenary talks by David Tall on information technology and mathematics education--enthusiasms, possibilities and realities and Jan de Lange on real problems with real world mathematics.

II. Content of Working Group and Topic Group Sessions

Working Group 16 - Role of technology in the mathematics classroom (Marcelo Borba, leader)

During the first meeting of this working group, an overview of scheduled meetings was provided; elementary, secondary, and university subgroups were formed; subgroup leaders were introduced; and Rina Hershkowitz of the Weizmann Institute delivered the talk on technology and the development of sociomathematical norms in the classroom.

Three subgroup meetings comprised the second Working Group 16 meeting. The university subgroup led by Jim Fey focused on eight points: 1) What questions/issues should the world be researching? 2) What are the issues or common concerns related to the use of technology? 3) Current technological tools (calculators, computer and various software, multimedia, lab-interfaces, and the internet); 4) Teacher roles (expositor, trainer, stimulator, guide, and manager); 5) Student roles (individual, group member, problem solver/poser, reporter, critic, practitioner, and explorer); 6) Tasks (open, structured, complex, simple, contextual, proof, and discovery); 7) Assessment (student projects, tool usage, and journal writing); and 8) What are experiences or concerns? The university meeting concluded with a presentation by Mary Margaret Shoaf-Grubbs on the role of technology in creating a positive learning experience in a first-year college mathematics course for the under-represented student at an all-women's liberal arts college.

A university subgroup session constituted the third meeting and included a presentation by Paola Valero on teachers' beliefs and technology in the classroom and small group discussions organized around the topics analysis/calculus, statistics, linear algebra, teacher/student roles, software tools, new math goals and student/ technology interaction. Each discussion group prepared a list of pertinent issues to be compiled and shared with the entire working group.

The final Working Group 16 meeting focused on reports given by each subgroup. Common themes for future discussion and research efforts related to the role of technology in the mathematics classroom emerged: (1) Changes in student thinking and motivation - student learning should be integrated rather than separated into different subjects. (2) Changes in mathematics and the curriculum - What mathematics will be taught? What topics should be omitted/decreased due to technology usage? The nature of mathematics tasks has and must continue to change. How does technology usage affect delivery methods? (3) Changes in teacher - teachers need long-term support to change from dispenser of predetermined curriculum to creator of innovative curriculum. Teachers must be provided as much time to become comfortable and confident with technology as students; they must be trained to be "good" users of technology. (4) Changes in educational system - either the system will change due to technology or assimilation will occur resulting in no change. (5) Changes in pedagogy - When technology is used in the study of mathematics, different problems, strategies, and materials must be employed to deepen student understanding. Technology encourages a more interactive environment and may necessitate reorganizing the mathematics classroom. (6) Changes in individual countries - Acknowledging that staff development is absent in many countries, our goal should be to move education toward the industrial norm of 10% spent on professional development. (7) Assessment of changes and Changing assessment - Can evidence be found which supports whether or not technology is effective in increasing student understanding of mathematics? Since current assessment tools may not measure the impact of technology on pedagogy, student thinking, and the curriculum, new assessment techniques should be developed.

Topic Group 18 - Role of calculators in the mathematics classroom (Pedro Gomez, leader)

The format of both meetings consisted of two 15-minute plenary talks, six five-minute short talks, and a question and answer session. Plenary speakers included Bert K. Waits on calculators with computer symbolic algebra--a look to the future; Jose Ramon Vizmanos Buelta on will algebra disappear with the use of graphic calculators?; Peter Jones on realizing the potential of the graphics calculator--towards the intelligent partnership; and Pedro Gomez on graphic calculators and mathematics education in underdeveloped countries. Short talks included John Berry on discovering advanced mathematics with calculator activities; Gregory D. Foley on the Texas Instruments TI-92 as a vehicle for the teaching and learning of functions, graphs, and analytic geometry; Thomas P. Dick on much more than a toy; Diane Resek on graphing calculators in the Interactive mathematics program curriculum; Fiona Grant on mathematical modeling with a graphics calculator; John F. Lucas on elementary differential equations on the TI-85; Patrick Scott on PLACEM--Latin American project for calculators in math education; Per Broman on possibilities and fears; Shin Watanabe on the change in the method in mathematical education with TI-82; Antonio Quesada on the impact of the first generation of graphing calculators on the mathematics curriculum at secondary and college levels; Jaime Carvalhoe Silva on are GC the catalyzers for a real change in mathematics teaching?; and Barry Kissane on graphics calculators and assessment.

III. What I Learned at ICME-8

Numerous commonalities were noted despite differences in how the teaching, learning, and assessment of mathematics is approached in other countries. Shared interests focus on improving the teaching of mathematics, studying and documenting how students learn, assessing the impact of technology, developing new assessment techniques and tools, and encouraging research in areas related to mathematics teaching and learning. Anna Sierpinska's opening day plenary talk set the stage for viewing the teaching of mathematics as more than the delivery of a mathematics curriculum. Her "action and improvement are what distinguishes mathematics education from mathematics curriculum" philosophy clearly conveyed the importance of interactivity both from the perspective of a learner and a teacher.

Consensus appears to exist among different countries on what conditions are necessary for improving the teaching of mathematics. The role of the teacher is to orchestrate student learning. Students should be guided to become a community of learners doing mathematics in meaningful ways and taking full responsibility for their learning. Mathematical problems and their solutions need to be meaningful, particularly since mathematical problem situations are more valuable than mathematical manipulations. Jan de Lange noted that much of what is currently labeled as real-world applications are not very good examples since they are not presented in an appropriate context. The teacher's task then becomes one of creating real problems for students that are relevant and taken from day-to-day, cultural, or scientific situations. Only then can students be successful in conceptualizing mathematics and formulating some level of generalization. It is the process of learning mathematics and solving a problem which is more important than the syntax or the solution itself.

In the words of David Tall, "Students can only learn what they see, feel, act on, and do for themselves." How students learn mathematics is varied and requires that learning activities allow for multiple learning styles. The inclusion of hands-on and discovery approaches, cooperative and individual tasks, and exploratory and constructivist are only a sampling of possibilities. Students should be encouraged to evaluate, criticize, and reflect upon their own thinking and processes as well as that of others.

The impact of technology on the teaching and learning of mathematics has been significant. Graphing calculators, computers, interactive software, and videos which were recently considered state-of-the-art technology have become accepted as standard technological teaching tools. "New" technologies such as the TI-92, multimedia, internet, and lab interfaces hold the promise of dramatically changing mathematics content and instruction. As Peter Jones explained, technology has the potential to enhance mathematical performance through the formation of intelligent partnerships since it can reduce the cognitive load which supports mathematical activity.

In the past, assessment has taken on many forms, the most recognizable of which is the single test administered in a formal setting which promises to ascertain what students know, understand, and can do. Current thought on the role of assessment in mathematics has centered around the increased use of a variety of assessment techniques and tools. The use of journal writing, portfolios, courseware, and presentations has become more popular as a more complete picture of student understanding and knowledge is sought.

Research presentations included Paola Valero's report on student and teacher behaviors with and without calculator usage. With calculators, students were actively involved in learning and doing mathematics and the teacher did not dominate classroom discussion, talking only 40% of the time. In contrast, without calculators, students were passive and the teacher dominated the discussion 64% of the time by giving student directions and lectures. Patricia Campbell's research report outlined how urban elementary mathematics classrooms were transformed based on the constructivist philosophy. Teachers were trained to assist students in building on prior knowledge, focusing on thinking rather than providing expected responses, and explaining or justifying responses or thinking.

From the perspective of a first-time ICME attendee, this congress had the effect of enlightening, stimulating, motivating, and supporting a one-year veteran college mathematics educator. The opportunity to interact with colleagues from around the world possessing similar as well as varied interests provided a powerful new lens with which to view mathematics education. Thought processes could not fail to be stimulated and motivated by the expertise and experiences shared by presenters and participants alike. My sincere appreciation is offered to both the arrangements committee, NCTM and NSF for making my participation in this congress possible.

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I. Sessions I Attended

All four sessions of Working Group 25 (subgroup 1 on the second and third day, presenter and recorder for this subgroup).

One session of Topic Group 23 on electronic publishing. (The topics announced for the second day were not relevant to my work on JRME, which was the reason I had selected to attend this topic group.)

All four plenary sessions.

Regular lectures by Howson, Moore, and Vergnaud. (Unfortunately, others I wanted to attend were closed by the time I was able to get from the working group post-discussion to the lecture rooms.)

Session for editors of journals in mathematics and mathematics education.

Many small discussions with a variety of people—some of whom wanted to talk to me about JRME publishing.

Social events such as the excursion (to Jerez), and the Andalusian dancers. Wonderful!

IIa. Content of the Working Group 25 Sessions: Didactics of mathematics as a scientific discipline

Day 1: Nicolina Malara, the working group organizer, provided an introduction and overview of the four sessions. A formal presentation was given to the working group by Hans-George Steiner. Steiner suggested that, pragmatically speaking, didactics of mathematics and mathematics education should be considered equivalent. He then proceeded to present the history of didactics of mathematics, noting the individuals who influenced its growth and development. This was, admittedly, a Eurocentric version of development, but one that others appeared to agree with, since other countries came to recognize this discipline later. Steiner then turned to discuss the role of didactics of mathematics as a scientific discipline, through its birth in 1908 at an ICMI conference, and its development though ICMI work and eventually through ICME conferences.

Days 2 and 3: Subgroup 1 focused on the development and status of didactics of mathematics in various countries. Reports were given from individuals representing the following countries: U.S. (I presented this report); Japan; the Czech republic, Spain, Belgium, Russia, Italy, and Venezuela. The reports varied a great deal in terms of their formats; some presented diverse views about didactics in their countries; some presented a report on the present status; some focused on teaching and others on research; some spoke only of their own personal research projects. I learned how recently the field of mathematics education, or "Didactics in mathematics," has been recognized as a legitimate discipline worthy of study in some countries, including Spain. The relationship of mathematics education with other fields and disciplines, e.g., mathematics, psychology, sociology, and philosophy varies by country. For example, the connection between didactics and psychology is very strong in Russia, but much less so in Japan. And yet, all reports were alike in that the focus was on improving instruction and student learning.

Day 4: A roundtable (in reality, a panel) was held on the final day, with both subgroups attending. To begin, the English-speaking members were separated from the Spanish-speaking members, and each group met to formulate some questions for the panel. Each group then presented their questions, and panel members attempted to respond. Steiner pointed out at the end that most of the questions asked have been discussed at length in some recently published books, including the Didactics of Mathematics as a Scientific Discipline edited by Beiler and others, and the Macmillan/NCTM Handbook, edited by Grouws, and gently chided the group for coming unprepared. He noted that if we do not read and build on the work of others, we will not progress.

IIb. Content of the Topic Group 23 on Future ways of publishing in mathematics education

The session began with an overview by König on what journals in mathematics and mathematics education are now in some electronic form on World Wide Web. (Some of the information later proved false during the editors' meeting. Obviously, this type of information is in flux.) The remainder of the session was devoted to discussion of issues and problems related to electronic publishing. For the most part, the issues discussed were not ones being discussed in the United States. Some of the reports were in Spanish and the English translations (on paper) were not comprehensible. As editor of JRME, I was looking forward to the discussions, hoping that I would learn something new, but I was disappointed that the issues important to the JRME Editorial Panel are little related to those of concern to members of this topic group.

III. What I Learned at ICME-8

Plenaries: I appreciated and enjoyed the plenaries on the last day, given by Tall and de Lange. Much of what they had to say was not unexpected, based on what I know of their work from previous talks and from reading their published articles. I was most interested in Sierpinska's presentation and expected to learn from her, but the difficulties with the sound system made coherence difficult. I look forward to reading the report. The Spanish plenary was less useful to me, and also suffered from difficulties with the sound system.

Lectures: The lecture presented by Howson, on mathematics and common sense, was masterful. Howson had recently reviewed eighth grade texts from various countries and found that all text authors tried to supply meaning to mathematics through real-word examples. This study of texts alerted him to possible dangers in such an approach. The following is a summary of his message: While we must, when possible, show how mathematics relates to the real world and helps us make sense of it, students reach a "fault-line" at about age 13, when they encounter the multiplication of negative numbers, which does not make sense in any real-world applications. This situation should not come as a surprise to us, since throughout history mathematicians have come up against ideas that they could not at the time accept; e.g., imaginary numbers, degrees of infinity. Gauss did not publish findings on hyperbolic geometry because he knew his work was an affront to common sense. Thus, the focus on common sense can make advancement in mathematics difficult. Mathematicians as a community have developed their own kind of "common sense" that has its basis in the organization of mathematics. The concepts of mathematics were built up "systematically for reasons that are both external and internal" (Hilbert). Howson's conclusion: We must ensure that students see mathematics not as a mere extension of common sense, but as a structural, organized discipline that builds on accepted shared results and techniques. There comes a time when mathematics transcends common sense. Howson's points have made me rethink the role of sense-making in my current project, developing curriculum materials for prospective elementary and middle school teachers.

The lecture by Vergnaud extended some of his past work. I have many times found his construct of "theorem-in-action" to be extremely useful in understanding students' reasoning processes. In this address he spoke more of "concept-in-action," that is, a category, or object, or predicate that is held to be present. Vergnaud then clarified what is meant by a scheme and how it applies to the learning of mathematics.

The context of David Moore's address was the democratization of mathematics education. He spoke of the changing content in statistics education, due to the influence of technology, and the synergy in statistics education between technology and content, between content and pedagogy, and then between pedagogy and technology. His many examples were particularly interesting.

Social interactions: I was fortunate to meet some JRME authors and reviewers that I had not met in the past. (Most I had met through PME.) I find it easier, in my position as Editor of Journal of Research in Mathematics Education, to correspond with people I have met and with whom I have discussed research issues. Of course, I met and talked with many old friends that I have made throughout the years, some of whom did not attend PME this year (or last year in Brazil). These international contacts are, I believe, particularly important in maintaining the international status of JRME. I found it interesting when Efraim Fischbein (Israel) told me that he did not feel comfortable submitting journal articles to an editor he did not know (alluding to the change of editorship of Educational Studies in Mathematics). Finally, I met briefly with Willi Dorfler, who told me of the changes in publishing that are taking place with Educational Studies in Mathematics. I suspect that authors will not like being removed from contact with the editors now that all correspondence is channeled through Kluwer. This may have implications for JRME in terms of an increased number of manuscripts being received in a year or two.

Problems: There were organizational problems that called for a great deal of patience. It was difficult not to compare the organization with the highly successful and well-organized PME meeting I had just attended. I devoted two afternoons to tracing the copies of JRME that had been sent for the Editors' meeting, without success.

However, there were a record number of people at ICME-8, far more than had been anticipated, and that type of success is certain to have repercussions on the organization. I was delighted to see and talk with so many attendees from underdeveloped countries. ICME-8 organizers are to be congratulated for their success in sponsoring many individuals who could not otherwise have attended.

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On the night before ICME-8 officially began, there was a meeting of those who received travel grants. Of the people receiving the awards, one had attended all the ICMEs (Jerry Becker) and I had attended all but the first. Perhaps it was because this was my seventh ICME, or perhaps because I am a member of the United States International Commission on Mathematical Instruction and received announcements and advance information slightly earlier than most people, I felt more at ease at this ICME than any other I had attended.

My comfort was not because I was well prepared for my presentation. At ICME-7 I had spent almost the entire week polishing the one-hour talk to give on the last day. The same pressure almost recurred even though I had finished a complete paper for Topic Group 2, Secondary mathematics, and sent it to the reactors two weeks before a June deadline.

The paper, "Directions of change in secondary mathematics education, and the difficulties they spawn," received a cordial reaction from Glenda Lappan, who suggested three things I might consider. The changes suggested were small enough that I felt I could make them the night before leaving Chicago. However, that evening, in reading again through the correspondence and the Congress's third announcement, I realized that I had made a large blunder and that Glenda was simply being kind. I had written a paper quite appropriate for Working Group 13, changes in secondary mathematics, and had ignored virtually all instructions given to me for the paper for Topic Group 2.

Fortunately, the first meeting of Topic Group 2 was not to occur until the fifth day of the congress, so there was time to prepare; on the plane from Chicago to Madrid, I took out the Powerbook that my wife Karen and I had brought with us and began writing the paper that was needed, "Big ideas in secondary mathematics." It attempted to meet Glenda's three suggestions: speak of the most important ideas; incorporate some of your own work; talk about symbol manipulators and their role. When I arrived in Sevilla, I sought out Glenda and asked her if my impressions were correct, and if I should continue the course of writing a new talk. She said she had wondered why my original paper was so off the mark and that it would be very nice if I worked on the new one.

The paper focused on four big ideas in secondary mathematics (in extension of elementary mathematics). (1) Mathematics (not just arithmetic) is useful. (2) Mathematical truth is established by deduction (and not by induction). (3) Algorithms are powerful procedures that allow entire classes of problems (not just individual problems) to be solved. (4) Representations and morphisms are powerful mechanisms for understanding and doing mathematics.

Because of the time frame in which the paper was written, I had no reaction before it was given. And so I was surprised that in the discussion that ensued, it became clear that big idea (2) was controversial. How much the community has changed in the thirty years since the new math era!

There was a question now of what to do with the prepared talk, and a very nice thing happened. At the first of four sessions of Working Group 13, Martin Kindt of the Netherlands outlined how the group would operate; it would split for most sessions into two subgroups – one for ages 11-14; the other for ages 15-18. Seven papers would be given in each subgroup. The final day was relatively unstructured. After the first session, I told Martin I had a paper that might be appropriate and he asked me to give him a copy at the next session; I did and by the end of the session he had read it and said it would be appropriate for the last day. Others read it and said that it would be appropriate for both subgroups, and so it became a culminating paper for the entire working group. It is nice to have this opportunity to thank Martin and the others who were so kind to me.

Once I knew I was to present this paper, a fun enterprise took place. Martin and his colleagues Mieke Abels and Michiel Doorman at the Freudenthal Institute had edited the 14 papers (into good English) and they were retyped and duplicated in a booklet that was given to all Working Group 13 attendees on the first day. Karen and I worked during the congress to put my paper into the exact same font, format, style, page setup, and paper size that was used in the booklet, and we made 150 copies of it. Many thanks to Karen, who at the on-site request of Working Group11 was also developing a presentation, "Zero-based curriculum from a publisher's perspective: How a publisher decides what to publish."

The congress was organized so that there was time for this writing in the afternoon. The formal part of the Congress ranged from 8:30 AM to 1:30 PM and included all Working Groups, the plenary and regular lectures, and Topic Groups. In fact, Sevilla was so hot (temperatures were 45°C during the Congress) that nothing else could be done during the afternoon. This schedule, which gave long breaks each day, contributed to one's comfort. Although the climate clearly was a factor in creating it, still a schedule like this may be something to duplicate at other meetings.

If one expects each ICME to be better than the last in all respects, then disappointment lurks. The opening ceremony, which took place in a hall that seated thousands, had too many introductions by officials. Also, it was difficult for many conferees to hear the speakers through the sound system. Immediately following the opening ceremony, the first plenary session speaker used overheads whose type was too small. The second plenary session speaker was also difficult to hear for some. However, at the end of the day we returned to this hall for an exciting cultural performance by an Andalusian dance troupe that was clearly world-class. Given that ICME-7 treated us to the now-famous (but then not so well-known) Cirque de Soleil, I am spoiled and can't wait to see what the Japanese have for us at ICME-9 in the year 2000.

The regular lectures were quite satisfying. Anna Sfard of Israel gave a talk in which she led many who had never heard her (like myself) to think that she was quite rigid in thinking about metaphors and models in mathematics, only to find that at the end she took an opposite position. It was either brilliant or insensitive, take your choice! Hiroshi Fujita, who has come to Chicago for two international conferences, gave the best talk I have ever heard him give – on the Japanese secondary school curriculum. The new curriculum consists of core courses and simultaneous optional courses. I doubt that it could be implemented in the United States but it is most interesting to contemplate. A talk by Urs Kirchgraber of Switzerland explained why we hear so little about the Swiss mathematics curriculum – it seems that each canton of Switzerland has its own. Victor Firsov of Russia gave a talk in which he stunned me by opening with "There is a myth about the very high level of education of

Russian students," and he went on from there. When I asked another Russian who had been in the audience whether Firsov's view is accurate (for in the U.S. people also disagree whether our system is working well), the response of the second Russian was that some people agree with Firsov, but it was clear that not all do.

I did not have an opportunity to hear the last two plenary session speakers, David Tall or Jan de Lange. However, the existence of Tall on the program spurred me to hear him when he came to the Chicago area in September, and I found someone who seems to share many views. I have heard Jan de Lange many times; and since he comes to the U.S. so often these days, we do not need an international conference to get together.

There were more commercial exhibits at this ICME than any other in my memory. Particularly striking was the fact that the two largest booths were those of Casio and Texas Instruments. Given the domination by TI of the U.S. calculator market, it was a small surprise to learn that Casio is the predominant calculator used in many other countries.

Ten projects gave presentations and ten others gave shows. Of these twenty, three were from the U.S., and the surprising thing is that none of the NSF-funded curriculum projects or any other large project was represented. Any impression of developments in the United States people from other countries received from the projects at this ICME is quite distorted. It would be worthwhile for the U.S. to get its act together. Perhaps we might endeavor to put together a two-part report on mathematics education in the U.S., one part showing data about the existing state of mathematics education, the other part dealing with projects and developments that are coming along.

It is important that we try hard to present an accurate picture of what is going on in our country, because the influence of the United States in mathematics education is at least as strong as ever. English is now entrenched as the second language of the world and our material can be understood by most leaders in mathematics education in every country. With the end of the cold war, almost all of the world's leaders in mathematics education have been to the United States, and I think they are impressed by the volume of work done here. Researchers from any country have a difficult time talking about their work without commenting on work done in the U.S. The NCTM Standards are known world-wide and were commonly referred to in talks with high regard.

The ease of travel has made everyone influence each other more. In Sevilla there were restaurants of a host of nationalities. There were three of our most famous fast-food establishments, all with good food. (I felt it to be a patriotic duty to check them out in case Bill Clinton asks me for an opinion.) There was an ATM machine in our hotel that gave a better exchange rate than any other place that exchanged money—if only we had known at the time! We selected Granada for our excursion-day destination because of the Alhambra and found traveling there by bus not much different than travelling by bus in the U.S.

But not all was well with travel. At the airport in Madrid on our way to Sevilla, we found out that a noted U.S. mathematics educator had money taken from her purse in the airport while she was holding on to it but asleep. We were warned to be careful about this. As a result of the organizers' concern for security, however, many meeting rooms were locked before and after sessions even when there were people to open them by the door and participants who wanted to be in. And, as a result, when on the last day I mistakenly left my large pad of notes (with my name on it) in a room, it was gone even 15 minutes later; and I could not get into the room to see if the pad had been thrown into a wastebasket.

The disaster of TWA Flight 800 occurred during ICME, and we had traveled on TWA. Having one fewer 747 in its fleet caused TWA to switch passengers to other flights on the way back, so we were put on Iberia to New York and then transferred to TWA for the flight to Chicago. Was there increased security? There was enough security to x-ray checked luggage, but not enough to keep someone from realizing through the x-ray that Karen had a computer and camera in her bag, to break the lock and to take everything of value. Thus, the final disk copy of the Topic Group 2 talk was lost.

Would these problems keep me from going to another ICME? Not in the least. An ICME remains the best conference outside of the United States, the best place to renew and develop new professional contacts, learn about what is going on in places similar and dissimilar to ours, obtain new perspectives about our work, and be reminded that mathematics is a universal language, a common bond that is our obligation to employ to continue to help the world become a better place.

Laura R. Van Zoest

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I. Sessions I Attended

I participated in Topic Group 2 on secondary school mathematics, organized by Glenda Lappan, and Working Group 19 on preparation and enhancement of teachers, organized by Marjorie Carss. I attended the following plenary sessions and regular lectures: Anna Sierpinska on Whither mathematics education?; Miguel de Guzman on the role of the mathematician in mathematics education; Carolyn Kieran on the changing face of school algebra; Thomas Cooney on conceptualizing the professional development of teachers; Konrad Kreiner on some considerations on problems and perspectives in mathematics teacher inservice education; Ole Skovmose on critical mathematics education - some philosophical remarks; and Alba Thompson on conceptual and calculational orientations in teaching mathematics. I was also involved in the Psychology of Mathematics Education study group and the games in the mathematics classroom workshop.

II. Content of the Working Group and Topic Group Sessions

Working Group 19 focused on the preparation and enhancement of teachers. Under that umbrella, the papers presented were divided into the categories of mathematics teacher knowledge and teacher beliefs, mathematics teacher education and information technologies, and mathematics teacher education programs. General sessions were held with brief presentations from all categories followed by break-out sessions that provided opportunities for discussion of specific issues. The presentations provided a context for the small-group discussions. A booklet containing abstracts of the presentations, given to us at the start of the working group, was especially helpful for providing an overview of research underway in teacher education. I found it particularly interesting to see that many different countries are struggling to find solutions to similar problems.

The break-out group that I participated in discussed field experiences for prospective teachers and, in particular, the interaction that occurs between practicing and prospective teachers during these experiences. We discussed ways that each group could be encouraged to positively influence the other to become reflective, reform-minded practitioners. As this is an area in which I focus my research and do a significant amount of teaching, I found these small sessions to be an important part of the conference. I was able to hear about the approaches of universities in different countries as well as other parts of the United States. The discouraging aspect of these conversations was that no one seemed satisfied with the methods they had tried. We developed far more questions than answers. At the end of the week, each small group made a brief presentation to the combined working group providing us with an idea of the conversations that had occurred during the week.

Topic Group 2 focused on secondary school mathematics. The topic group began with presentations by Jan de Lange and Zalman Usiskin on the big ideas of mathematics. These presentations were interesting individually, but more so because they were given side-by-side. Through their differing perspectives, both speakers provided a basis for further discussion about what is valued in mathematics and what should be the focus of mathematics teaching and learning. The question that I was most interested in was, "What is the interaction between new curricula, new instructional strategies, new assessment strategies and the professional development of teachers?" Jan de Lange, in speaking about implementing technology, summarized the ideal in this way: "Teachers carrying out an innovation they believe in with politics supporting them." It seems to me that this generalizes to reform curricular materials and reflects the wide information net mathematics educators must cast if we are to truly reform mathematics education.

In the concluding meeting of the topic group, Glenda Lappan quoted Jerome Bruner on new curriculum, "If it cannot change, move, perturb, inform teachers, it will have no effect on those who teach it." Now that the new curricula are becoming available, we need to provide teachers with opportunities to be affected by them. The topic group did a good job of addressing some of the ways in which teachers have been asked to change and laid a foundation for further work on what we as teacher educators need to do to help them meet these challenges.

III. What I Learned at ICME-8

In reflecting upon what I learned at ICME-8, the first thing that comes to mind is a heightened awareness of how many people from all over the world are interested in improving mathematics education. Connected to that was the new understanding of how many of the problems and challenges in mathematics education that I had considered to be unique to the United States are, in actuality, shared by a wide variety of countries. Much of what I learned was subtle and personal, such as people from countries that differ greatly from the United States share the same goals for their mathematics teachers that I do. I had not anticipated, for example, meeting a group from Israel who is running a teacher development program very similar to, and with the same objectives as, ours at Western Michigan University. It is my hope that as this particular relationship continues to grow, our different cultural perspectives will provide us with insight that would not have been possible had we limited our circle of influence to only those from our own country.

ICME-8 also provided me with the opportunity to think deeply about what it means to do mathematics education research. These thoughts were initiated by Anna Sierpinska's opening plenary talk and stimulated by other talks throughout the week as well as conversations with colleagues from around the world. This was a particularly opportune time for me to engage in these discussions as I am at the beginning of what I hope will be a long research career. I left ICME-8 with a much stronger sense of the direction I want to head and the way my research can contribute to the larger research picture. Furthermore, the research about practicing high school mathematics teachers that I am currently engaged in was reinforced by reports from similar studies.

I also learned that although field experiences for prospective high school mathematics teachers are something that many of us find extremely important, there has not been much research on the success of different approaches or even on the ways in which these experiences influence future teaching. This was both disappointing to me because I had hoped to find some answers, and encouraging as it supported my belief that this would be a fruitful area in which to focus my research. I found Tom Cooney's talk very beneficial in this regard as it was based on one of the few projects that focus on prospective high school mathematics teachers. The relationship between student beliefs and their approaches to teaching is both fascinating and depressing. It raises the question in my mind of how much impact teacher educators can have on students who come through our programs if they do not have beliefs that are compatible with the experiences they have in our classes. Following from that is the question of whether we need to be more selective about who enters mathematics teacher education programs. This, in turn, raises significant equity issues such as whether teacher educators have the right to tell someone that, based on their beliefs, they will not be allowed to be a mathematics teacher. On the other hand, producing additional teachers who will need significant professional development to teach mathematics successfully for all children cancels out the progress that is currently being made. Perhaps the solution is to remember that teacher education is something that goes on during the entire career of a teacher and to develop connections between teachers and their teacher education programs that last long beyond a four- or five-year sequence of courses and field work. To support this we need to move, as Cooney suggested, beyond teacher education being simply an activity to its being a disciplined inquiry.

The knowledge that I gained from talks such as Alba Thompson's and Carolyn Kieran's, though not directly related to my research, will have an impact on my teaching. Current ideas about the organization and components of mathematical knowledge provide a context for the graduate and undergraduate courses that I teach to prospective and practicing teachers. Kieran discussed different types of algebra (generational, transformational, global) and different approaches that can be taken to algebra (spreadsheets, graphical/functional, symbolic). She stressed the importance of finding a middle ground and that symbolism is acceptable and necessary. Thompson talked about three aspects of the mathematics curriculum: the calculational curriculum, the curriculum of processes, and the conceptual curriculum. She identified signs of an overemphasis on the calculational curriculum and the symptoms of teachers who identify with conceptual and calculational curriculums. I expect that the identification of these perspectives will be helpful in planning professional development activities for teachers who ascribe to the differing perspectives.

Other less tangible benefits of attending the conference included the opportunity to meet many of the people whose works I had read. Seeing and hearing leaders in the field of mathematics education from around the world present their current thinking on topics in mathematics education was inspiring. The challenge, of course, is to carry these feelings through the mundane daily tasks that can sap our creative energy and limit our productivity. Attending ICME-8 helped me to refocus on the big picture of mathematics education. I look forward to sharing what I learned from ICME-8 with my students and colleagues.

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I. Sessions I Attended

I was the Chief organizer (CO) for Working Group 21 on the teaching of mathematics in different cultures. In addition to spending considerable time before the congress organizing the scientific program, it demanded a great deal of time during the congress and outside the working group sessions. I had the responsibility to collect as many of the papers to be presented in the working group as possible before reaching Sevilla, and Xerox and distribute them, and to do the same with others collected in Sevilla. Beyond this, there were responsibilities in connection with scheduling and rescheduling speakers and arranging for the facilities—rooms, air conditioning, blackboards, microphones, OHPs and screens, and so forth. I had no idea that being a CO would be so immensely time consuming. Still the Spanish organizers arranged for excellent facilities and support—for example, when I inquired the day before the Congress about the facilities for our group, two Spanish mathematics students, both English speakers, were assigned to assist me.

Beyond my own group, I participated in Topic Group 26 on international comparative investigations, and presented a paper. I also attended the opening session of the congress and heard the round table discussion and all the plenary speakers, and also several of the regular (plenary) lectures: Changpei Wang, Hiroshi Fujita, Paulos Gerdes, Hans Schupp (cancelled), and Doug Brumbaugh. As all congress delegates agreed, the evening cultural performance by the Andalusian Dance Troupe was outstanding—truly magnificent. Similarly for the mid-congress excursion to the magnificent Alhambra, with its geometrical art.

I also attended the ICMI Studies, ICMI Assembly and Richard Skemp Memorial sessions. Finally, as one of only eight remaining "old hands" (mathematics educators who have participated in all eight ICMEs), I enjoyed an excellent intimate dinner with the other "old hands" at the Jamaica Restaurant near the University. The dinner was hosted by Professor Jose Luis Vicente, Chair of the algebra section of the mathematics department, and was arranged by the Local Organizing Committee in our honor: Claude Gaulin and John Egsgard, Canada; Geoffrey Howson and Alan Bell, United Kingdom; Erich Ch. Wittmann and Hans-Georg Steiner, Germany; Shmuel Avital, Israel; Jerry Becker, United States.

II. Content of the Working and Topic Group Sessions

In Working Group 21, one hundred thirty-five delegates from 28 countries carried out their work from the premise that the teaching of mathematics in different countries has commonalities and that there are many aspects to these. In the first plenary session, Terezinha Nunes opened the session by starting from the idea that mathematics is a cultural practice that is situated in time and space and is defined by the community of mathematicians. According to Nunes, if mathematics is a cultural practice, then to learn mathematics is to become socialized into its particular ways of knowing. Nunes discussed this process of socialization of the mind from a psychological perspective while offering an integrated view of psychological theories and research. The main sections of her presentation were: 1) Is relativism a consequence of a cultural view of mathematical knowledge? 2) The socialization of meanings into mathematical concepts. 3) Mathematical signs as tools for thought. 4) Values associated with the learning of mathematics in and out of school. 5) Implications for mathematics teaching in a multicultural society. The paper set the stage for discussions in subsequent sessions.

Bill Barton presented the second plenary talk. He mentioned that the aims of mathematics education are inextricably linked with the socio-cultural aims of education. In order to provide a mathematics curriculum that is fair to all students in a multicultural society, it is necessary to unravel these links so that they can be clearly seen, and in this way, minority cultures in the mathematics classroom can be given space and legitimacy. Barton described these links with a model of socio-cultural nets that is used to develop strategies for mathematics course development and delivery in multicultural environments. It was illustrated with the history of Maori mathematics in New Zealand.

In the next two sessions, participants worked in four subgroups:

Subgroup 1: The influence of culture on teaching and curriculum – The five presenters each briefly summarized their papers and discussion then followed. In the discussions, curriculum was included in addition to mathematics, teaching, and culture. Further, the papers and discussions extended the terms sociology, psychology and schemata (webs) from the two initial plenary presentations in the following emergent ways: the possibilities to extend the curriculum by using traditional knowledge that has mathematical components but requires a different approach to curriculum; the prominent differences in teaching styles that exist even between cultures that are similar; the link between all aspects of mathematics and culture and, borrowing from the literature from gender studies, a tentative theoretical framework for the development of culturally inclusive curricula emerged; various problems were shown that can occur with language development; and finally, the language concerns and links between culture and learning styles emerged. The discussion was extended to include the matter of class, especially city/rural and the need to consider the political aspects related to the subgroup's topics. Overall, the discussions pointed first to the need to consider the practical issues that impact on teachers such as overfull curricula and a lack of resources, and secondly, to the rich variation and complexity of the influence of culture even though many similarities exist across disparate cultural groups.

Subgroup 2: Preparing teachers to teach to diversity – The ten presenters each briefly summarized their papers and discussion followed. The papers dealt with the challenge of diversity in one form or another, and all of them directly or indirectly addressed the preparation of teachers for diverse student populations. The main emergent points were as follows: (a) Regarding diversity of cultural expectations, in some cultures a child-centered method of teaching in which the teacher facilitates his/her students' construction of mathematical knowledge is expected. In others, the teacher is expected to be an authority figure, with an answer for every question. Although the latter view may not be considered progressive, it must be respected for instruction to be effective. (b) Regarding diversity of students' "webs," it was acknowledged that students bring different "webs" to the classroom. Teaching to diversity means recognition of this fact, taking care not to destroy students' webs while empowering them to modify or extend their webs in ways that will

give them greater access to mathematical understanding and competence. (c) Regarding the importance of ethnomathematics, the mathematics education of children should begin, when appropriate, with the mathematics of their "cultural practice"; i.e., their ethnomathematics. Two papers actually suggested that ethnomathematics be part of teacher education curricula. Unless this is done, teachers may not see ethnomathematics as "authentic mathematics." The discussions also raised the point that the curricula of teacher education should include courses in minority history, language and culture. Overall, the papers provided a model for the mathematical enculturation of students along with examples of cultural elements that had mathematical aspects. There was a consensus that for mathematics instruction to be effective, it must be culturally responsive.
Subgroup 3: Cross-cultural research - Here it was first recognized that while cross-cultural studies have been done that compare curriculum, teaching methods, or mathematics classroom practices, there still are only a few studies that investigate how students actually learn mathematics under different emphases in classroom teaching. In the first of three presentations, a study of how students incorporate formalized school knowledge and skills into the thinking which they bring into their classroom was reported. Prior to instruction, students' performance on common problems was compared, and during instruction, four students in a U.S. and four in a Japanese classroom were studied using a qualitative research approach. Students' behaviors were synthesized into twelve patterns. There were no great differences in terms of patterns reported. Rather, the differences emerged more in the ways in which students work in their seats: one was the roles of the teacher and peers in the students' process of learning, and the other was the extent to which students were concerned with procedural and representational aspects of the new methods. Students were found to share their strategies that were different from those taught by the teacher.

Another study reported the results of comparative investigations between mathematics classroom practices in the U.S. and Japan. Six lessons in Japan and four in the U.S. were analyzed. The lessons focused on a common mathematical problem. For each lesson, the videotape, transcription and lesson plan were analyzed. The case studies provided evidence of differences between U.S. and Japanese mathematics classroom practices. A discussion emerged regarding a "mathematically convincing" vs. "personally convincing" aspect of the lessons.

It was observed that the Japanese teachers tended to make comments regarding students' work that was based on mathematical sophistication; i.e., which solution is the best mathematically. In contrast, the American teachers regarded each solution as equally important; i.e., they seemed to be accepting of each solution while not evaluating it. An emergent theme was that the Japanese lessons aim at more mathematically sophisticated activity in contrast to the U.S. In the U.S. lessons, most of the time was devoted to group work in problem solving whereas, most of the time in the Japanese lessons was given to comparing and discussing solutions and to summarizing the lessons.

In the third presentation, it was reported that in the U.S. half of fourth-grade students are still in the process of constructing place value concepts, whereas Asian students develop this concept much earlier. Research was conducted in the first grade that incorporated several components from the Japanese curriculum, including a de-emphasis on counting as a strategy, explicit naming of numbers (e.g., "ten-three" for 13), and a sub-base of five to make quantities visualizable. There were many significant differences when compared to the control class and to other research.

Subgroup 4: Mathematics learned outside school – Three papers were presented and discussed. The main emergent points were as follows: (a) In trying to interest children in algebra and in introducing them to algebra, there is a dialectical tension inside mathematics, namely, between formal school mathematics and informal street mathematics. The passage from arithmetic to algebra is a complex process: mapping (1st stage), natural language to formal language (2nd stage), algebraic manipulation (3rd stage), and a proposition of an answer to the problem (4th stage). A didactic sequence was proposed using a two-pan balance scale (that is common in children's lives) to introduce algebra. Based on theoretical considerations and an emphasis on representations, it can be expected that symbolic systems can be conceptual amplifiers--however, they can be misleading and they are not "the real thing." (b) When considering models of proportional reasoning among indigenous Maori girls in New Zealand, in the context of cooking, these girls were able to reason and to think mathematically ... and the context is "out of school." By relating the outside school knowledge to the experiences of these girls in school, they can be reasoned about and articulated. In this way, connections and links are more likely to be made, and this may facilitate transfer and generalization across the contexts. (c) Regarding the experience that is concerned with the mathematics that students use outside school and teachers' perspectives of those mathematical activities in students' lives, the discussion revealed that (i) mathematics exists outside of school; (ii) it is useful to introduce or discuss out-of-school mathematics in the classroom to improve a skill(s) and then consciously use it again outside of school; (iii) there is a need to exercise restraint in emphasizing students' reflection on mathematical aspects of their lives, just in case they might stop doing it altogether.

In the fourth session that was plenary, Richard Pallascio discussed the learning of geometry by Inuit--a problem of mathematics acculturation. Pallascio reported on research that was carried out by Louise Lafortune, Richard Allaire, Pierre Mongeau and himself aimed at developing an understanding of Inuit spatial skills. In the presentation, Pallascio dealt with: 1) The matrix of the development of geometric spatial representation. 2) Types of space. 3) Elements of the theoretical framework. 4) The results and discussion of the research. Subsequently, the researchers carried out a didactical sequence, and in the process, were able to isolate the main characteristics of a contextualized, culturally committed and involved pedagogy that was described.

Though she was not able to come to Seville, the organizing committee was delighted to have Martha Villavicencio's paper (in both Spanish and English) that reported the results of research that was concerned with mathematical education in Andean bicultural contexts. The conclusion that Villavicencio offered was that the low achievement of boys and girls in Andean bicultural contexts in mathematics was due to (i) a lack of consideration of their cultural sociolinguistic context--it is necessary to carry out qualitative transformations at a technical-pedagogical level, and (ii) the qualitative improvement of mathematical education in contexts of autochthonous sociocultural groups supposes a political decision of the State for the adequate implementation of intercultural programs of good quality. Janet Kaahwa also contributed a paper that was concerned with the need for mathematics educators to explore mathematics in local environments and cultures and to also use it to interest learners in mathematics and to facilitate learning. In her study in Uganda, Kaahwa used cultural objects and explained the mathematics embedded in them both verbally and in diagrams. She concluded that, though ethnomathematics is quite new in Uganda, there is a wealth of mathematics in its culture and environment that can be used to enrich mathematics teaching and learning. D. J. van den Berg also shared a paper in which he indicated that a group-oriented teaching strategy is essential in the South African educational system in order to bring the related skills in line with those required by the modern South African economy. Finally, Tamsin Roberts shared his paper on the development of a mathematics curriculum framework that can be used by individual Aboriginal communities in Australia to develop a curriculum that reflects the needs and aspirations of these communities.

We had only four 1.5-hour sessions in which to deal with many important topics closely linked to teaching mathematics in different cultures. We made very good progress. More time would have made it possible to produce more results from in-depth discussion and, perhaps, even make some specific recommendations for further work. However, we had a very high level of attendance, and the plenary papers, short presentations and intensity of discussion led us to conclude that both the format and the working group theme were "on the mark" to achieve our goals: the main papers set the tone, the summaries of papers sparked discussion, and the participants shared and gained insights.

Several people made extraordinary contributions to the success of our group: to the Local Organizer, Mr. Andres Marcos Garcia, and to Ms. Estela Villalba Valdayo, a student worker, we express great appreciation for their steady and effective cooperation and support; and to Dr. Luis Ortiz-Franco, an American participant, we express profound appreciation for his voluntary translation support in the plenary sessions, as well as in the subgroup discussions—he contributed immensely to the success of the group's work. A proceedings containing the plenary and subgroup papers will be published. Information is available from: Jerry P. Becker, Department of

Curriculum and Instruction, Southern Illinois University, Carbondale, Illinois 62901-4610, U.S.A. The e-mail address is JBECKER@SIU.EDU

In Topic Group 26, Professor T. Sawada, Y. Shimizu and I reported on our U.S.-Japan cross-cultural study of students' problem solving behaviors. The paper will appear in the group's proceedings, published by Falmer Press, edited by Gabriele Kaiser. Overall, the talks I attended provided an excellent overview of the major aims of international comparative studies and also the main limitations (cf. Postlewhaite (1988)/see Fran Curico's report in this book). Of particular note was a need for a "healthy skepticism" with respect to overall achievement findings in cross-national studies and a need for smaller cross-national studies with particular foci (e.g., the videotape study that is part of TIMSS).

III. What I Learned at ICME-8

Beyond the above, in many of the talks and discussions, including the national reports and certain poster sessions, it seems that classroom practitioners and researchers are searching for better links between research and reform. This points to questions like: "What evidence is available that is helpful to reformers?" "What areas of research merit the attention of teachers?" "How should research be influenced by innovative practices?" "What should efforts to reform curricula and teaching expect from research?" And other such questions. The bottom line seems to be that there are no clear answers to questions like these yet, and that more discussion is needed among researchers, practitioners and those who propose innovations; at the very least, it does not seem that research-based general principles abound by which curricular or teaching reform can be given direction. Of course, there are many congress papers that remain to be read yet, but it does not seem that ICME-8 has yielded research findings that can directly assist the reform movement in the U.S.

The plenary talks given at the congress were interesting and useful. Miguel de Guzman spoke on the theme of the role of the mathematician in mathematics education. For him, the main goal of the mathematical community should be to contribute to the development of human culture. To do this, it is necessary to solve problems that the natural development of mathematics poses, preserve and transmit the mathematical legacy and share mathematical successes and their power to society. Inside the global mathematical community there are mathematicians, teachers whose task is to transmit knowledge, researchers in mathematical education, users of mathematics, and the "popularizers" and "expositors" of mathematics. In the talk we were reminded that mathematicians need to be involved in mathematics education because (i) they create mathematics and most profoundly perceive the value and beauty of it and (ii) they are the most immersed into it—and so are the best to guide the adequacy of the methods of education for younger ones. They have a role to play in orienting the educational processes, assess correctness of innovations, and to help avoid the dangers of a unilateral vision of educational problems. Euler, Klein, Hadamard, Polya, and Santalo are examples of mathematicians with a deep and beneficial influence on the evolution of mathematics education. de Guzman believes mathematicians can help to design new forms of learning at the school levels, help to incorporate new tools into mathematics education and assume a role in making mathematics more visible to society.

In his plenary talk, Jan de Lange discussed real problems with real world mathematics. He identified the problem: To create suitable contexts, or how to find a good match between real worlds and real mathematics. This question was addressed by Freudenthal at ICME-4 in Berkeley in his paper on "Major problems of Mathematics Education." Following Hilbert, who presented 23 mathematical problems to be solved (Paris, 1900)—that would presage the development of mathematics for a century—Freudenthal posed and discussed 13 important problems for mathematics education in the future (e.g., How to create suitable contexts in order to teach mathematizing?) So, a key issue is to devise good real-world problems (i.e., a mathematical problem in a context meaningful to the learner). de Lange presented many examples related to this theme and also discussed various related problems—for example, good real-world mathematics education means that teaching will be more complex, and educating teachers to teach in this way will be extremely challenging. This may turn out to be the most difficult problem to tackle in reforming mathematics curricula and teaching.

David Tall attempted to make sense of the impact of information technology on mathematics education. He began with an awareness of technological changes, but then focused on how they interact with the nature of human learning. He considered the nature of mathematical knowledge in order to explore how its different parts are affected by technology. His ideas of enactive, visual and symbolic ways of learning are well served by use of a computer and he discussed each in a section: Enactive and visual mathematics; Symbolic mathematics; Long-term difficulties with symbols; and the Mutual roles of the visual and the symbolic. In the end, he concludes, there may no longer be a need to prepare children to use regular mathematical routines, but they will have to grow, in their mathematical education, in a way to survive in the midst of swift technological change—this will require making sense of the relationship between various processes, concepts and representations in what they are taught. This will continue to require the guidance of good teachers. Thus, teacher preparation and inservice education exist as significant challenges.

In her presentation, Anna Sierpenska viewed developments in mathematics education as "programs" (e.g., "constructivism" and "problem solving"). She sees a program as evolving on three planes—the planes of ideology, theory, and didactic action. She examined the New Math and ended with a conclusion that trying to bend reality to an ideology runs against mathematics education as a domain of research producing scientific knowledge. For me, her eventual question, at the end, was important: Could it be that mathematics education encounters difficulties in rising to a recognized discipline due to the concern about its foundations, whereas, it might be more useful if it aimed at producing more than meta-results and valued these results at least equally to the meta-results? Would more proper or useful results be those in the form of design and justification of didactic action?

ICME-9 is not far into the future. Perhaps travel grant awardees for ICME-9 should spend some time before that congress identifying the most pressing issues that bear on the relation of research to reform here in the U.S. In doing so, perhaps questions such as:

- What should be the relation of research to reform?
- What components of reform are supported by research?

- What can reform expect of research?
- What mathematics should students learn?
- Can all students learn important mathematics?

and others could be formulated in a way to guide what can be learned at ICME-9 that would serve to enhance research work in the U.S. and the reform of content, teaching, assessment, and technology use in U.S. mathematics education. Could we, through the ICMEs, join research to reform in the U.S.?

Finally, the Arrangements Committee sought financial support to prepare an authoritative document (book) on U.S. mathematics education and new developments, for distribution at a national presentation in Sevilla. Unfortunately, we were not successful in this regard. However, support should again be pursued in connection with ICME-9 in Japan to prepare such a volume that gives a current, comprehensive and in-depth perspective of the state of mathematics education in the U.S. I think the international community of mathematics educators would welcome it.

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I. Sessions Attended

During the ICME-8, I attended the plenary sessions; the meetings of Working Group 18 on adults returning to mathematics education; the two sessions of Topic Group 5 on education for mathematics in the work place; and a number of regular lectures including Christine Keitel's teaching maths anxiety–A circulus of aversion to mathematics with teachers and students; Pearla Nesher's school stereotype word problems and the open nature of applications; Rudolf Straesser's mathematics for work–A didactical perspective; and Geoffre Howson's mathematics and commonsense. In addition, I attended the Australian National Presentation, the exhibits and poster sessions.

II. Content of the Working Group and Topic Group Sessions

Working Group 18 on adults returning to mathematics education is a newly formed working group. It met for the first time at ICME-8. This working group focused on the unique needs of adults who are studying the basic mathematics they did not learn earlier in their lives either because of lack of opportunity for schooling or because they themselves were unable to benefit from school instruction when they were younger. The major goals of the sessions of the working group were threefold: (1) to share among the participants information from many different countries about the approaches, priorities, and activities being undertaken that aim to improve the effectiveness of program design and instruction for this population of mathematics learners; (2) to establish a network of mathematics educators that can facilitate the transfer of information and ideas across national boundaries; and (3) to formulate an agenda for ongoing work to improve mathematics education for adults. Recognizing the different settings within which adults return to mathematics education, the working group was divided into two subgroups that focused on (1) adults preparing to enter the university and (2) adults studying basic mathematics for vocational and personal goals.

I participated in the second subgroup which felt that the allotted time was insufficient for this unique opportunity to share and discuss adults' mathematics learning and thereby voted to extend the scheduled meeting times.

Presentations from Spain, Ireland, the United Kingdom, Australia, Israel, Brazil, the Netherlands, Denmark, and the United States informed participants of ongoing projects and provided contexts for discussion. Research on how adult learners think about the mathematical tasks they do outside of class and on the apparent incongruities between the mathematical skills learned in class and the mathematical skills adults display in everyday life contexts were presented and discussed. Additional presentations concerned the political impact of knowing basic mathematics, the implications of the NCTM's Curriculum and Evaluation Standards for adult mathematics education, the development of instructional activities that are engaging and meaningful to adult learners, theories and practice of staff development for teachers of adults, and the development of an assessment program that reflects adults' mathematical knowledge in the contexts of decontextualized mathematics, everyday experiences, and the workplace.

For the two meetings of Topic Group 5 on education for mathematics in the work place, presentations were grouped around two themes: (1) methodologies being used to elicit useful information about how mathematics is used in workplace environments and (2) instructional models that attempt to address the problem of transfer from classroom-based learning of mathematics to workplace applications of mathematics. Additionally, copies of Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus were distributed and the rationale and development process of the document were described.

The methodologies described by researchers seeking to determine how mathematics is being used in workplaces included observing and shadowing workers for significant periods of time, organizing observations to find patterns, trying to determine if workers are aware of the mathematics that underlies the information they retrieve and use to make decisions, and exploring the presuppositions or language registers that may underlie behaviors involving mathematics in the work environment versus a school environment.

The instructional models designed to bring the workplace closer to the mathematics classroom to facilitate transfer of knowledge included using workplace case studies or authentic work-based examples to improve motivation while identifying general mathematics competencies that can be mapped back onto practice. Of continuing concern is the tension between approaching mathematics education as developing a body of ideas and processes that are generalizable to many workplaces and the demands of a specific workplace for relevant, context-useful knowledge and skills.

III. What I Learned at ICME-8

A number of themes meandered through the discussions of adults' returning to mathematics education, whether at the university level or at the adult basic education level. Participants from every country emphasized that adult learners of mathematics are different from young learners of mathematics; the adults are motivated by real-world imperatives, bring a wealth of life experiences including perhaps very negative attitudes and beliefs about mathematics and their ability to succeed, and represent extremely varied populations. These characteristics suggest that the content of the adult basic mathematics curriculum, the instructional setting and methods of instruction, and attention to the unique concerns of the learner as an adult in our society (perhaps with extensive, pressing economic and familial concerns) may be quite different from that which is considered appropriate for students at the K-12 level. Ongoing research and experimentation is required for us to learn more about how to meet the needs of the adult learners effectively.

My own research reveals that when adults in the U.S. return to basic mathematics education, they are frequently motivated by a desire to enter the workforce, qualify for a training program, or improve their work-related skills to enable professional advancement. From the information communicated by fellow participants at ICME-8, goals such as these are recognized in other countries as well and are frequently supported by extensive networks of government sponsored vocational education programs and curricula geared particularly for the adult population. This educational endeavor is enhanced by assessments that seek to identify the skills adult learners bring to their education and to inform the design of instruction so that it can build upon those skills.

Designers of assessments and curricula are struggling with the realization that the mathematics that is typically taught in school may not easily transfer to tasks in the workplace and the mathematics that is mastered in the workplace may be so context bound that it also does not easily transfer to new settings. Yet, since an important goal of adult basic mathematics education is to enable adults to participate in the workforce, we must consider beginning in the workplace rather than with the abstract body of mathematics.

Research shows that many adults are able to handle mathematical activities within the workplace or in their own everyday functions but perform poorly on isolated, decontextualized mathematical exercises. We must therefore investigate how knowledge is transmitted within the workplace from the expert to the novice, how people make sense of mathematics in their personal lives, that is, how people learn mathematics in these informal contexts. Then, since most mathematics instruction for adults takes place in classrooms in preparation for the workplace, the culture, content, and instructional processes of American adult mathematics education classes may need to change to resemble the workplace more than the K-12 classroom. This change may require a shift from school-based tasks to authentic tasks, with a corresponding revision of the technologies that are available during learning, the social relationships among class members and instructors, the level of precision required for solutions and resulting ways of computation, and the contextual information that must be applied to achieve a meaningful solution within a context.

Researchers and mathematics educators are continuing to explore issues relating to the mathematical education of adults in diverse settings in many countries around the world. When we establish professional contacts and relationships among the members of this educational community, we often find that what is learned in one place can be applied somewhere else or may, at least, inform a new direction of exploration.

General Overview of the Reports

Overall, most awardees reported that one of the best experiences they had at ICME-8 was the opportunity to meet with colleagues and to share problems, concerns, and ideas. All agreed that the discussions were useful. Many were surprised at the connectedness they felt with mathematics educators from other parts of the world and with the commonality of goals of the participants at ICME-8. Professional contacts of this type strengthened some pre-conceived ideas of participants, while there is cause to reformulate or enhance others. Many participants came away from Sevilla with a renewed belief in the importance of communication and cooperation among all members of the international educational community.

The use of technology has the potential to be a powerful force for change in education. Aside from the usual problems of finding funds to acquire technology, participants also had many deep concerns. One concern that was repeatedly expressed was the need to use technology to enhance content rather than letting the technology drive the content. The use of technology, whether it be graphing calculators, computer programs, or communication facilities, tends to decentralize the role of the teacher in the classroom. Rather than a lecturer, the teacher becomes a planner of lessons and problems that allow students to explore, investigate, and communicate. Students must have technology skills that are automated enough to make use of the powerful technology for exploration. In the meantime, students must still learn to use strong thinking processes and acquire deep conceptual knowledge.

Although concerns were great, some helpful ideas began to emerge from discussions. In order to have an effective curriculum, the whole school should be involved in planning. For those educators who are concerned about using graphing calculators, the suggestion was made that these be used for only part of assignments or assessments. Since students sometimes have trouble connecting the mathematics they learn in the classroom to that which they use in the computer laboratory, concepts and ideas should be presented to students in multiple representations. It helps to have the technology in the classroom instead of in a separate laboratory. For this reason, teachers may have more success with using graphing calculators instead of computers.

Teachers, administrators, and students need to become acclimated to the use of technology. Teachers need professional development opportunities that allow them to feel confident in the planning and implementation of lessons that employ technology. They need computer software and hardware that will support their lessons and teaching. To this end, teachers need to communicate about their needs with the authors and publishers of software.

The classroom teacher is the primary deliverer of the curriculum. Therefore, it is not surprising that much of the discussion at the congress centered on teacher attitudes, professional development opportunities, and preservice experiences. Many participants were surprised to discover how much teacher attitude influences instruction. Many elementary teachers are plagued with mathematics anxiety. Even some secondary teachers are anxious when it comes to abstract concepts that do not lead to an immediate correct answer. This may be a serious problem, since present trends in mathematics education are toward exploration and discovery.

There is no question that teachers need to be confident and well-versed in mathematics. They need to move forward in their understanding of mathematics and to experience problem-solving situations. This requires meaningful professional development for teachers, and it should be a sustained effort that is grounded in content and that is supported by administration.

There was a general agreement among the participants that the training of teachers should be reviewed and upgraded. Preservice teachers should be educated to deliver a broad-based curriculum. Both elementary and secondary preservice teachers need to be sufficiently educated in mathematics and in pedagogy, and their school-based experiences should be meaningful. The better students should be encouraged to enter teaching, and those students should explore their own attitudes toward teaching. Teacher educators need to listen to classroom teachers, to maintain close ties to schools (and that reality), and to become facilitators and guides for preservice teachers.

Many of the participants agreed with the constructivist stance on the creation of mathematical knowledge. They expressed the belief that mathematics education should be exploratory in nature. Just as traditional mathematics was constructed over time by human beings, students need time to develop and to organize their own mathematical schemes. Many participants expressed the idea that this is the only way that conceptual learning can take place. The teacher's task is to create real problems that will be meaningful to students.

Although the constructivist stance recognizes the individuality and the experiences of students, it can be problematic as well. Teachers wondered how they might deal with students who are slow in making meaning of what they experience. Some believed that there are times when one must take a more formal absolutist stand about mathematics. Indeed, although constructivism seems to be well accepted among ICME-8 participants, there is still some feeling among mathematicians and educators around the globe that mathematics is a thing to be studied rather than a thing to be constructed.

There was a strong interest among the participants in the teaching of problem solving. There is a great need for problems that engage students and help them see the value of the mathematics lessons learned. Problems should balance the need to know process with the need to know content. Students should learn diverse methods and use diverse tools in problem solving. There is evidence that when students engage in complex problem solving in groups, they share knowledge in order to accomplish the task.

When students and adults work and play in the real world, they use mathematics. They plan, they estimate, they use functions, and they learn efficient mathematical processes that they need for the situation. In fact, students can be efficient learners. They learn in different ways, and teachers must provide a variety of methods to accommodate these differences. Teachers often want to allow more time for students to plan and carry out tasks, but they are often intimidated by the prospect of standardized testing and mandated curriculum.

As the curriculum is revised, the need for effective methods of assessment becomes a concern. Some alternate methods of assessment of student understanding are through interviews of younger students, portfolios, journal writing, and individual and group presentations. Many countries do not allow the use of graphing calculators on national exams. However, the United States, the United Kingdom, Sweden, and Denmark do. Assessment might involve the use of other tools as well.

There were other concerns raised throughout the congress that were fairly specific. There was a good deal of support for not teaching the standard computational algorithms to elementary students. Memorizing seems to have a negative effect on learning in these grades. There was some concern, however, about the difficulty of totally eliminating algorithms. For higher level students, for example, algorithms provide students with the power to solve classes of problems and to move on to higher learning.

Participants took home many effective ideas and suggestions: The history of mathematics can be incorporated into lessons; mathematics teachers may cooperate with teachers in other disciplines such as art and science; an integrated curriculum across mathematics subjects such as algebra and geometry might enhance the teaching of both; students seem to learn a great deal through well-planned projects; perhaps mathematics teachers should emphasize clarity rather than precision; and, finally, students of different ages are motivated differently. From elementary school to adult education, the student should be considered in planning meaningful mathematical experiences.

Several participants were surprised to learn that many countries are now facing the issue of equity in education at least on some level. Traditionally, marginalized populations in many countries received rote learning at best. As communication and trade make the world a smaller place and as the need for an educated workforce becomes stronger, more and more countries are struggling with the problem of providing a quality mathematics curriculum for all students, regardless of age, gender, socio-economic class, ethnic background, or physical disabilities. Mathematics educators must overcome the belief that mathematics is culture free. Culture, background, and value systems affect all areas of learning. Curriculum planners must face the task of overcoming mathematics anxiety and making the learning of mathematics a positive and meaningful experience for all.

Several participants were impressed with the great need for support for research in mathematics education. There is a need for experimental research that can be replicated and shared with the educational community. There is also a need for good qualitative research. The United

States provides a good deal of leadership in the mathematics education community. Researchers should share what they are doing with the global community, and this should be a major focus of each congress.

All participants took away with them much to think about and to share with fellow educators at home. Sometimes more questions were raised than answers were provided, but the opportunity to openly discuss problems and issues in mathematics education provided a first step toward solutions.

APPENDICES

APPENDIX I

ROSTER TRAVEL GRANTS/ICME-8
Committee on Arrangements of NCTM

Name	State	Gender	Ethnic	Level	WG#	TG#	Previous ICMEs
Elementary/Middle School							
Juana Wilson	TX	F	H	ES	12	10	N
Brenda Hammond	DC	F	B	ES	14	6	N
Monica Chi-Benedetti	AK	F	A	ES	9	10	N
Maria Gomez	CA	F	H	ES	21	1	N
Fanny Sosenke	IN	F	H	MS	4	13	N
Frederick Uy	NY	M	A	MS	21	16	N
Jane Ryder	TX	F	B	MS	16	19	N
George Abshire	OK	M	W	MS	1	10	N
Sheryl Riley	KY	F	W	ES	22	1	#7
High School/Supervisor							
Evan Glazer	IL	M	W	HS	16	19	N
Roberta Koss	CA	F	W	HS	16	2	#5,6,7
Dan Teague	NC	M	W	HS	13	17	#7
Mark Saul	NY	M	W	HS	7	24	#6,7
Dick Seitz	MT	M	W	HS	11	13	N
Cheryl Cleaves	TN	F	W	CC	9	5	N
Donna Simpson	IL	F	B	S	15	18	N
ThereseJones	TX	F	W	S	22	4	N
Sherry Cox	TN	F	W	HS	16	16	N

University/Community College

Peggy House	MI	F	W	U/TE/S	21	7	#3,4,5,6
Jack Alexander	DC	M	B	U/S	15	17	N
Mary Lindquist	GA	F	W	U	12	26	#4,5,6,7
Glenda Lappan	MI	F	W	U	19	2	#6,7
Miriam Leiva	NC	F	H	U	13	19	#6
Raymond Guzman	CA	M	H	CC	10	11	N
Margie Hobbs	TN	F	W	CC	9	7	N
Sunday Ajose	NC	M	B	U	21	21	#4,7
Helen Doerr	NY	F	W	U	15	17	N
Lynnell Matthews	MD	F	B	CC	16	4	N
Jacek Kostyrko	AK	M	W	CC	10	15	N
Victor Katz	DC	M	W	U	19	8	#6,7

Teacher Education/Research/Adult Education

Tom Cooney	GA	M	W	R	2	2	#3,4,5,6,7
Judy Sowder	CA	F	W	R	25	23	#7
Lynda Ginsburg	PA	F	W	A	18	5	N
Doug Grouws	IA	M	W	U/TE/R	12	19	#4,5,6
Fran Curcio	NY	F	W	TE	14	26	#6,7
Joanne Rossi Becker	CA	F	W	TE	6	2	#4,5,6,7
Beatrice D'Ambrosio	IN	F	W	R	26	6	#5,6,7
Lillie Albert	KY	F	B	TE	9	10	N
Laura Van Zoest	MI	F	W	TE	19	2	#7
Judy O'Neal	GA	F	W	TE	16	18	N
Zal Usiskin	IL	M	W	U/R	13	2	#2,3,4,5,6,7

Arrangements Committee

Sadie Bragg (MSEB)	NY	F	B	U	16	13	N
Jack Price (NCTM/Past President)	CA	M	W	TE	(Did not attend ICME-8)		
Linda Rosen (NCTM/Exec. Director)	VA	F	W	S	11	20	#7
Marilyn Mays (AMATYC)	TX	F	W	CC	17	5	#7
John Dossey (USNCMI)	IL	M	W	U	12	26	#4,6,7
Jerry Becker (USNCMI-Committee Chair)	IL	M	W	U/TE	21	23	#1,2,3,4,5,6,7
Gail Burrill (NCTM President)	WI	F	W	HS	13	9	#6, 7
Alan Schoenfeld (MAA)	CA	M	W	U	(Did not attend ICME-8)		

Legend: ES - Elementary School
MS - Middle School
HS - High School
S - Supervisor
CC - Community College
U - University
TE - Teacher Education
A - Adult Education
R - Research

M - Male
F - Female

H - Hispanic
B - Black
W - White
A - Asian

Under ICMEs: N - None
# - the number of the ICME attended (e.g., "4" means ICME-4)

ICMI-1: Lyon, France; ICME-2: Exeter, UK; ICME-3: Karlsruhe, Germany; ICME-4: Berkeley, U.S.; ICME-5: Adelaide, Australia; ICME-6: Budapest, Hungary; ICME-7: Quebec, Canada

APPENDIX II

WORKING GROUPS

WG 1:	Communication in the classroom	2	Abshire, Albert
WG 2:	Forms of mathematical knowledge	1	Cooney
WG 3:	Students' attitudes and motivation	0	
WG 4:	Students' difficulties in learning mathematics	0	
WG 5:	Teaching mixed-ability classes	1	Sosenske
WG 6:	Gender and mathematics	3	Gomez, Albert, J. R. Becker
WG 7:	Mathematics for gifted students	2	Gomez, Saul
WG 8:	Mathematics for students with special needs	0	
WG 9:	Innovation in assessment	1	Chi-Benedetti
WG 10:	Languages and mathematics	2	Guzman, Kostyrko
WG 11:	A curriculum from scratch (zero-based)	2	Seitz, Rosen
WG 12:	Curriculum changes in the primary school	5	Hammond, Wilson, Grouws, Dossey, Lindquist
WG 13:	Curriculum changes in the secondary school	3	Burrill, Teague, Usiskin
WG 14:	Linking mathematics with other school subjects	2	Bragg, Curcio
WG 15:	The impact of technology on the mathematics curriculum	4	Simpson, Mays, Alexander, Doerr
WG 16:	The role of technology in the mathematics classroom	5	Ryder, Cox, Glazer, Koss, Matthews
WG 17:	Mathematics as a service subject at the tertiary level	1	Mays
WG 18:	Adults returning to mathematics education	3	Cleaves, Hobbs, Ginsburg
WG 19:	Preparation and enhancement of teachers	4	Katz, Lappan, Leiva, Van Zoest
WG 20:	Evaluation of teaching, centers, and systems	0	
WG 21:	The teaching of mathematics in different cultures	4	J. P. Becker, Uy, Kostyrko, Ajose, House
WG 22:	Mathematics, education, society, and culture	2	Riley, Jones
WG 23:	Cooperation among countries and regions in mathematics education	1	Saul
WG 24:	Criteria for quality and relevance in mathematics education research	0	
WG 25:	Didactics of mathematics as a scientific discipline	1	Sowder
WG 26:	Connections between research and practice in mathematics education	1	D'Ambrosio

TOPIC GROUPS

TG 1:	Primary school mathematics	1	Riley
TG 2:	Secondary school mathematics	8	Koss, Seitz, J. R. Becker, Cooney, House, Lappan, Usiskin, Van Zoest
TG 3:	University mathematics	0	
TG 4:	Distance learning of mathematics	3	Saul, Jones, Matthews
TG 5:	Education for mathematics in the working place	2	Mays, Ginsburg
TG 6:	Mathematics teaching from a constructivist point of view	2	Hammond, D'Ambrosio

TG 7:	The fostering of mathematical creativity	0	
TG 8:	Proofs and proving: why, when and how	1	Katz
TG 9:	Statistics and probability at the secondary level	0	
TG 10:	Problem solving throughout the curriculum	4	Burrill, Chi-Benedetti, Abshire, Albert
TG 11:	The future of calculus	2	Guzman, Kostyrko
TG 12:	The future of geometry	0	
TG 13:	The future of algebra and arithmetic	2	Sosenske, Bragg
TG 14:	Infinite processes throughout the curriculum	0	
TG 15:	Art and mathematics	1	Alexander
TG 16:	History of mathematics and the teaching of mathematics	2	Uy, Katz
TG 17:	Mathematical modelling and applications	2	Teague, Doerr
TG 18:	Roles of calculators in the classroom	1	Simpson
TG 19:	Computer-based interactive learning	3	Wilson, Ryder, Glazer
TG 20:	Technology for visual representation	2	Rosen, Grouws
TG 21:	Mathematics instruction based on manipulative materials	1	Ajose
TG 22:	Mathematical games and puzzles	0	
TG 23:	Future ways of publishing in mathematics education	1	Sowder
TG 24:	Mathematics competitions	2	Cox, Saul
TG 25:	Mathematics clubs	0	
TG 26:	International comparative investigations	4	J. P. Becker, Curcio, Dossey, Lindquist

PLENARY

36 **Anna Sierpinska**/*Whither mathematics education?:* J. P. Becker, Chi-Benedetti, Hammond, Wilson, Abshire, Ryder, Sosenske, Uy, Glazer, Koss, Seitz, Teague, Jones, Simpson, Mays, Guzman, Kostyrko, Matthews, Alexander, J. R. Becker, Cooney, Curcio, D'Ambrosio, Doerr, Grouws, House, Katz, Dossey, Lappan, Leiva, Lindquist, O'Neal, Sowder, Usiskin, Van Zoest, Ginsburg

33 **Miguel de Guzman**/*On the role of the mathematician in mathematics education*: J. P. Becker, Hammond, Chi-Benedetti, Wilson, Abshire, Ryder, Sosenske, Uy, Glazer, Koss, Seitz, Teague, Jones, Simpson, Mays, Guzman, Matthews, Albert, Alexander, J. R. Becker, Cooney, D'Ambrosio, Grouws, House, Katz, Dossey, Lappan, Leiva, O'Neal, Sowder, Usiskin, Van Zoest, Ginsburg

20 **David Tall**/*Information technology and mathematics education: enthusiasms, possibilities and realities*: J. P. Becker, Chi-Benedetti, Abshire, Ryder, Sosenske, Uy, Glazer, Koss, Seitz, Teague, Guzman, J. R. Becker, D'Ambrosio, Doerr, House, Katz, Leiva, O'Neal, Sowder, Ginsburg

19 **Jan de Lange**/*Real problems with real world mathematics*: J. P. Becker, Chi-Benedetti, Abshire, Ryder, Sosenske, Uy, Glazer, Seitz, Teague, Guzman, J. R. Becker, D'Ambrosio, Doerr, House, Leiva, O'Neal, Sowder, Ginsburg